PALÆONTOGRAPHICAL SOCIETY.
VOL. XXIX.

CARBONIFEROUS FLORA.
PART IV.
(SIGILLARIA AND STIGMARIA.)

PAGES 97—147; PLATES XIX—XXIV.

CRETACEOUS ECHINODERMATA.
VOL. I; PART VII.
(ECHINOCONIDÆ, ECHINONIDÆ, ECHINOBRISSIDÆ, ECHINOLAMPIDÆ, AND SPATANGIDÆ.)

PAGES 225—264; PLATES LIII—LXII.

FOSSIL TRIGONIÆ.
No. III.

PAGES 93—148; PLATES XX—XXVII.

MESOZOIC REPTILIA.
PART II.
(BOTHRIOSPONDYLUS, CETIOSAURUS, OMOSAURUS.)

PAGES 15—93; PLATES III—XXII.

ISSUED FOR 1875.

PALÆONTOGRAPHICAL SOCIETY.

VOLUME XXIX.

CONTAINING

THE FLORA OF THE CARBONIFEROUS STRATA. Part IV. By Mr. E. W. Binney. Six Plates.

THE CRETACEOUS ECHINODERMATA. Vol. I, Part VII. By Dr. Wright. Ten Plates.

THE FOSSIL TRIGONIÆ. No. III. By Dr. Lycett. Eight Plates.

THE FOSSIL REPTILIA OF THE MESOZOIC FORMATIONS. Part II. By Prof. Owen. Twenty Plates.

ISSUED FOR 1875.

DECEMBER, 1875.

THE PALÆONTOGRAPHICAL SOCIETY was established in the year 1847, for the purpose of figuring and describing the *whole* of the British Fossils.

Each person subscribing One Guinea *is considered a Member of the Society, and is entitled to the Volume issued for the Year to which the Subscription relates.*

Subscriptions are considered to be due on the First of January in each year.

All the back volumes are in stock, and can be obtained (one or more) on application to the Treasurer or the Honorary Secretary.

The volumes are delivered free of carriage to any address within three miles of the General Post-Office, and are booked to any place beyond the three-mile radius; but in the latter case the carriage must be paid by the Member to whom they are sent.

Gentlemen desirous of forwarding the objects of the Society can be provided with circulars for distribution on application to the Honorary Secretary, the Rev. Thomas Wiltshire, 25, Granville Park, Lewisham, London, S.E.

The Annual Volumes are now issued in two forms of Binding: 1st, with all the Monographs stitched together and enclosed in one cover; 2nd, with each of the Monographs in a paper cover, and the whole of the separate parts enclosed in an envelope.

Members wishing to obtain the Volume arranged in the latter form are requested to communicate with the Honorary Secretary.

LIST

OF

The Council, Secretaries, and Members

OF THE

PALÆONTOGRAPHICAL SOCIETY;

AND

A CATALOGUE OF THE WORKS ALREADY PUBLISHED;
A CLASSIFIED LIST OF THE MONOGRAPHS COMPLETED, IN COURSE OF PUBLICATION, AND IN PREPARATION, WITH THE NAMES OF THEIR RESPECTIVE AUTHORS;
THE DATES OF ISSUE OF THE ANNUAL VOLUMES;
A GENERAL SUMMARY, SHOWING THE NUMBER OF THE PAGES, PLATES, FIGURES, AND SPECIES IN EACH MONOGRAPH;
AND A STRATIGRAPHICAL LIST OF THE BRITISH FOSSILS FIGURED AND DESCRIBED IN THE YEARLY VOLUMES.

Council and Officers elected 16th April, 1875.

President.

J. S. BOWERBANK, LL.D., F.R.S., G.S.

Vice-Presidents.

E. W. Binney, Esq., F.R.S., G.S.
T. Davidson, Esq., F.R.S., G.S.
Prof. Owen, C.B., F.R.S., G.S.
T. Wright, M.D., F.R.S.E., G.S.

Council.

Prof. Balfour, M.D., F.R.S.
H. C. Barlow, M.D., F.G.S.
J. J. Bigsby, M.D., F.R.S., G.S.
Sir A. Brady, F.G.S.
Sir P. de M. G. Egerton, Bart., M.P., F.R.S.
R. Etheridge, Esq., F.R.S., G.S.
R. Hudson, Esq., F.R.S., G.S.
J. W. Ilott, Esq.
J. Gwyn Jeffreys, LL.D., F.R.S., G.S.
H. Lee, Esq., F.L.S., G.S.
E. Meryon, M.D., F.G.S.
Prof. Prestwich, F.R.S., G.S.
T. Sopwith, Esq., F.R.S., G.S.
Prof. Tennant, F.G.S., Z.S.
Capt. C. Tyler, F.L.S., G.S.
H. Woodward, Esq., F.R.S., Z.S.

Treasurer.

Searles Wood, Esq., F.G.S., Beacon Hill House, Martlesham, Woodbridge, Suffolk.

Honorary Secretary.

Rev. T. Wiltshire, M.A., F.G.S., 25, Granville Park, Lewisham, London. S.E.

Local Secretaries.

Alton—W. Curtis, Jun., Esq.
Bath—Rev. H. H. Winwood, M.A., F.G.S.
Belfast.—Prof. R. O. Cunningham, F.L.S.
Berlin—Messrs. Friedländer & Son.
Birmingham—W. Mathews, Esq., F.G.S.
Blackburn—W. Harrison, Esq., F.G.S.
Bristol—W. Sanders, Esq., F.R.S., G.S.
Cambridge—James Carter, Esq.
Cheltenham—Dr. T. Wright, F.G.S.
Cirencester—J. Bravender, Esq., F.G.S.
Colchester—Dr. C. R. Bree.
Dublin—Dr. W. E. Steele, F.R.D.S.
Edinburgh—Prof. Balfour, M.D., F.R.S., L.S.
Glasgow.—J. Thomson, Esq., F.G.S.
Guildford—R. A. C. Godwin-Austen, Esq., F.R.S.
Kendal—Thomas Gough, Esq.
Leicester—James Plant, Esq., F.G.S.
Liverpool—G. H. Morton, Esq., F.G.S.
Malvern—Dr. R. B. Grindrod, F.G.S.
New York.—B. Waterhouse Hawkins, Esq., F.L.S., G.S.
Norfolk—Rev. J. Gunn, M.A., F.G.S.
North Devon—Townsend M. Hall, Esq., F.G.S.
Oxford.—Prof. Prestwich, F.R.S.
Paris—M. F. Savy, 77, Boulevard St. Germain.
Richmond, Yorkshire—E. Wood, Esq., F.G.S.
Scarborough—J. Leckenby, Esq., F.G.S.
Tonbridge Wells—J. Sharp, Esq., F.G.S.
Torquay—W. Pengelly, Esq., F.R.S., G.S.

LIST OF MEMBERS.*

CORRECTED TO SEPTEMBER, 1875.

Her Most Gracious Majesty the Queen.

Adams, William, Esq., F.G.S., Cardiff, Glamorganshire.
Adlard, J. E., Esq., Bartholomew Close. E.C.
Albert Memorial Museum, Queen Street, Exeter, per W. S. D'Urban, Esq., F.L.S., Curator.
Aitken, John, Esq., J.P., F.G.S., Lane End, Bacup, Manchester.
Anderson, Sir James, F.G.S., 16, Warrington Crescent. W.
Angelin, Professor, Stockholm.
Ansted, Professor D. T., M.A., F.R.S., For. Sec. G.S., &c., Athenæum Club. S.W.
Arbuthnot, Major W., 25, Hyde Park Gardens. W.
Archibald, J. W., Esq., Devonvale, Tillicoultry.
Asher and Co., Messrs., 13, Bedford Street, Covent Garden. W.C.
Athenæum Library, Liverpool.
Austen, Rev. J. H., M.A., F.G.S., Ensbury House, Wimborne, Dorset.
Austen, Miss Helena E., St. Asaph, North Wales.
Australia, Acclimatization Society of.
Aveline, W. T., Esq., F.G.S., Museum of Practical Geology, Jermyn Street. S.W.

Backhouse, Edward, Esq., Ashburne House, Sunderland.
Bain, James, Esq., 1, Haymarket, S.W.
Baker, A. F., Esq., Trinity College, Dublin.
Balfour, Professor, M.D., F.R.S., L.S., &c., *Local Secretary*, 27, Inverleith Row, Edinburgh.
Balfour, F. M., Esq., Trinity College, Cambridge.
Balme, E. B. Wheatley, Esq., Loughrigg, Ambleside.
Balston, W. E., Esq., F.G.S., Bearsted House, Maidstone.
Barbados, The Right Reverend John, D.D., D.C.L., Bishop of; Hon. Canon of Canterbury; Barbados.
Barclay, Joseph G., Esq., 54, Lombard Street. E.C.
Barlow, H. C., M.D., F.G.S., 11, Church Yard Row, Newington Butts, Surrey. S.
Barr, William Roby, Esq., F.G.S., New Bridge Mill, Stockport.
Barthes and Lowell, Messrs., 14, Great Marlborough Street. W.
Barnstaple Literary and Scientific Institution.
Bath Royal Literary and Scientific Institution.

* The Members are requested to inform the Secretary of any errors or omissions in this list, and of any delay in the transmission of the Yearly Volumes.

Bathurst, Rev. W. H., Lydney Park, Gloucester.
Beaufoy, George, Esq. (Executor of the late), South Lambeth. S.
Becker, M. Edvald, Breslau, Silesia.
Beckles, S. H., Esq., F.R.S., G.S., 9, Grand Parade, St. Leonard's-on-Sea.
Bedwell, F. A., Esq., Fort Hall, Bridlington Quay, Yorkshire.
Belfast Naturalists Field Club.
Bell, Professor T., F.R.S., L.S., G.S., &c., The Wakes, Selborne, Alton, Hants.
Benson, Starling, Esq., F.G.S., Swansea.
Berthand, Prof., Macon.
Bewley, John, Esq., 4, Brown's Buildings, Liverpool.
Bibliothèque du Muséum, Paris.
Bibliothèque du Palais des Arts, Lyon.
Bigsby, J. J., M.D., F.R.S., G.S., 89, Gloucester Place, Portman Square. W.
Bilke, Edward, Esq., F.G.S., &c., 1, Chester Square, Pimlico. S.W.
Binney, E. W., Esq., F.R.S., G.S., &c., *Vice-President*, 55, Peter Street, Manchester.
Birmingham Free Library, Radcliffe Place, Birmingham.
Birmingham Natural History and Microscopical Society, 90, Ryland Street, North, Birmingham.
Birmingham Old Library, Union Street, Birmingham.
Blackmore, Humphrey P., M.D., Salisbury.
Blake, Rev. J. F., M.A., F.G.S., Clifton, York.
Blake, W., Esq., Bridge House, South Petherton.
Blanford, H. F., Esq., F.G.S., 21, Bouverie Street, Whitefriars. E.C.
Boase, H. S., M.D., F.R.S., G.S., &c., Seafield House, Magdalen Place, Dundee.
Bonissent, Monsieur, Clarentau.
Bonney, Rev. George, F.G.S., St. John's College, Cambridge.
Bordeaux, La Faculté des Sciences de.
Borradaile, Charles, Esq., East Hothly, Uckfield, Sussex.
Bosquet, Mons. J., For. Cor. G.S., Pharmacien, Maestricht.
Boston Society of Natural History, Boston, U.S.A.
Bowerbank, J. S., LL.D., F.R.S., &c., *President*, 2, East Ascent, St. Leonard's-on-Sea.
Bowie, Mrs., 43, Palace Gardens Terrace, Kensington. W.
Brady, Sir Antonio, F.G.S., Stratford, Essex.
Braikenridge, Rev. G. W., M.A., F.C.S., S.A. Scot., Clevedon, Somerset.
Brassey, Thomas, Esq., 56, Lowndes Square. S.W.
Bravender, John, Esq., F.G.S., *Local Secretary*, The Firs, Cirencester.
Bree, C. R., M.D., *Local Secretary*, East Hill, Colchester.
Briggs, Miss Ellen, 55, Lincoln's Inn Fields. W.C.
Brighton and Sussex Natural History Society, Brighton.
British Museum, Departmental Mineralogical and Geological Library. W.C.
British Museum, Printed Book Department. W.C.
Brodie, W. R., Esq., Langton Matravers, Wareham.
Brooke, Sir Victor, Bart., Colebrooke Park, Brookborough, Ireland, and 53, Eaton Square, London.
Broome, C. E., Esq., M.A., &c., Elmhurst, Batheaston, Bath.
Brown, Edwin, Esq., F.R.G.S., G.S., Burton-on-Trent.
Brown, Hugh Horatio, Esq., 6, Derwent Street, Derby.
Brown, Isaac, Esq., Kendal.
Brown, T. C., Esq., Cirencester.

Brown, T. Foster, Esq., Guildhall Chambers, Cardiff.
Browne, Wm. Meredith, Esq., Westminster Fire Office, King Street, Covent Garden. W.C.
Buckley, Sir Edmund, Bart., M.P., F.L.S., Plas Dinas, Mawddwy, Merionethshire.
Buckman, Professor James, F.G.S., &c., Bradford Abbas, Sherborne, Dorset.
Busk, George, Esq., F.R.S., L.S., &c., 32, Harley Street, Cavendish Square. W.
Buxton, Rev. F. A., Easneye, Ware.

Cambridge University Library.
Capel, the Rt. Rev. Monsignor, D.D., Kensington. W.
Cardiff Free Library.
Carpenter, Alfred, M.D., Croydon. S.
Carpenter, W. B., M.D., F.R.S., &c., 56, Regent's Park Road. N.W.
Carter, James, Esq., *Local Secretary,* 30, Petty Cury, Cambridge.
Cash, Wm., Esq., Elmfield Terrace, Savile Park, Halifax.
Cavell, Edmund, Esq., F.G.S., Saxmundham.
Champernowne, Arthur, Esq., Darlington Hall, Totness, Devonshire.
Chapman, Thomas, Esq., 14, Cockspur Street, Charing Cross. S.W.
Chapman, Thomas, Esq., F.R.S., 25, Bryanstone Square. W.
Cheltenham College.
Cheltenham Permanent Library, 18, Clarence Street, Cheltenham.
Cherbullier, Mons., Paris.
Chicago, Library of.
Christ's College, Cambridge, Library of.
Clabon, J. M., Esq., 21, Great George Street. S.W.
Clark, J. Willis, Esq., Scroope House, Trumpington Street, Cambridge.
Clarke, Rev. W. B., F.G.S., &c., St. Leonards, near Sydney, New South Wales.
Clayton, Rev. J. H., Liphook, Hants.
Cobbold, Rev. R. H., The Rectory, Ross.
Cocchi, Sig. Q., Professor of Geology, Florence.
Colchester, W., Esq., F.G.S., Springfield House, Ipswich.
Cole, W. M., Esq., 93, St. Helen Street, Ipswich.
Collings, Rev. W. T., M.A., F.L.S., G.S., Lord of Sark, Hirjel House, Guernsey, Channel Islands.
Collinson, Henry, Esq., 7, Devonshire Place, Portland Place. W.
Cooper, Charles J., Esq., Bridgenorth, Salop.
Cornalia, Prof. Emilio, Milan.
Cornthwaite, Rev. T. M.A., Walthamstow.
Corporation of London, Library Committee of, Guildhall. E.C.
Cotteau, Mons. G., Auxerre.
Coutts, Jas., Esq., 310, Argyle Street, Glasgow.
Craig, R., Esq., Langside, Beith, Ayrshire. N.B.
Crisp, F., Esq., 134, Adelaide Road. N.W.
Cross, Rev. J. E., Appleby Vicarage, Brigg, Lincolnshire.
Crosskey, Rev. H. W., 28, George Road, Birmingham.
Crowley, Alfred, Esq., Bramley Oaks, Croydon. S.
Cubitt, George, Esq., M.P., 17, Princes Gate. W.
Cull, R., Esq., F.S.A., R.G.S., 13, Tavistock Street, Bedford Square. W.C.
Cunnington, W., Esq., F.G.S., Argyll House, 361, Cold Harbour Lane, Brixton. S.W.

Currey, Eliot S., Esq., The Wallands, Lewes, Sussex.
Curtis, W., Esq., *Local Secretary*, Alton, Hants.
Cust, Lady Elizabeth, 13, Eccleston Square. S.W.

Darwin, Charles, Esq., M.A., F.R.S., G.S., &c., Down, Beckenham, Kent.
Davidson, Thomas, Esq., F.R.S., G.S., Mem. Geol. Soc. France, &c., *Vice-President*, 3, Leopold Road, Brighton.
Daw, E., Esq., Braughing, Ware.
Dawkins, W. Boyd, Esq., F.R.S., G.S., Birch View, Norman Road, Rusholme, Manchester.
Dawson, Principal J. W., LL.D., F.R.S., G.S., &c., McGill's University, Montreal.
Day, Rev. Hen. Geo., M.A., St. Leonard's House, Ludlow.
De Grey and Ripon, Earl, Carlton Gardens. S.W.
Deighton, Bell, & Co., Messrs., Cambridge.
Deshayes, Prof. G. P., F.M.G.S., Paris.
Deslongchamps, Prof., Caen.
Devonshire, Duke of, Chancellor of the University of London, F.R.S., G.S., &c., Devonshire House, Piccadilly. W.
Devon and Exeter Institution, Exeter (by Ed. Parfitt, Esq.).
Dewalque, Prof., F.C.G.S., Liége.
Dickinson, F. H., Esq., King Weston, Somerton.
Dickinson, W., Esq., Thorncroft, Workington.
Dickinson, W., Esq., 6, Princes Street, Lothbury. E.C.
Digby, Lord, Minterne, Gerne Abbas, near Dorchester.
Dorset County Museum Library, Dorchester.
Douglas, Rev. Robert, Manaton Rectory, Moreton-Hampstead, Exeter.
Dover Proprietary Library.
Dowson, E. T., Esq., Geldeston, Beccles.
Doyen, Mons. J. M.
Ducie, the Earl of, F.R.S., G.S., &c., 16, Portman Square, W.; and Tortworth Court, Falfield, R.S.O., Gloucestershire.
Dudley and Midland Geological and Scientific Society and Field-Club.
Duff, J. Esq., Linden House, Teuters Street, Bishop Auckland.
Dumortier, Mons. E., Lyons.
Duncan, Prof., P. M., M.B., F.R.S., G.S., 40, Blessington Road, Lee. S.E.
Duncanson, J., Esq., The Walk, Alloa., N.B.
Durham, the Dean and Chapter of (by Samuel Rowlandson, Esq., the College, Durham).

Eccles, James, Esq., 15, Durham Villas, Phillimore Gardens, Kensington. W.
Edinburgh Geological Society, 5, St. Andrew Square, Edinburgh.
Edinburgh Museum of Science and Art, Argyle Square, Edinburgh.
Edwards, F. E., Esq., F.G.S., 22, Woburn Square. W.C.
Egerton, Sir Philip de Malpas Grey, Bart., M.P., Trustee Brit. Museum, F.R.S., G.S., &c., Oulton Park, Cheshire; and 28B, Albemarle Street. W.
Elliot, John, Esq., F.R.C.S., Kingsbridge, Devon.
Elliot, Sir Walter, K.S.I., F.L.S., Wolfelee, Hawick, N.B.
Enniskillen, William Willoughby, Earl of, D.C.L., F.R.S., G.S., &c., Florence Court, Enniskillen; and 65, Eaton Place.
Errington, The Reverend Dr., Prior Park, Bath.
Eskrigge, R. A., Esq., G 17, Exchange Buildings North, Liverpool.

Etheridge, R., Esq., F.R.S., G.S., &c., Museum of Practical Geology, Jermyn Street. S.W.
Evans, John, Esq., F.R.S., Pres. G.S., Nash Mills, Hemel Hempstead.
Eyton, Thomas C., Esq., F.L.S., G.S., &c., Eyton, near Wellington, Salop.

Falconer, Thomas, Esq., F.G.S., Usk, Monmouthshire.
Falkner, Frederick, Esq., Somersetshire Bank, Bath.
Favre, Mons. Alph., Professor of Geology, Academy, Geneva.
Ferguson, William, Esq., F.R.S.E., L.S., G.S., R.G.S., &c., Kinmundy, Mintlaw, Aberdeenshire.
Fisher, Rev. Osmond, M.A., F.G.S., Harlston Rectory, Cambridge.
Fletcher, Colonel T. W., M.A., F.R.S., G.S., S.A., Lawneswood House, Stourbridge.
Flower, John, Esq., Fairfield Road, Croydon, S.
Forbes, John Edward, F.G.S., 3, Faulkner Street, Manchester.
Fordham H. G., Esq., Odsey, Royston, Herts.
Fotherby, H. J., M.D., 3, Finsbury Square. E.C.
Fox, Rev. W. Darwin, Delamere Rectory, near Chester.
Fraser, John, M.A., M.D., F.R.C.S. Edin., Wolverhampton.
Friedländer, Messrs., *Local Secretaries*, 11, Carlstrasse, Berlin.
Fritsch, Prof. K. von, Halle.
Fuller, Rev. A., Ichenor Rectory, Chichester.

Galton, Captain Douglas, R.E., F.R.S., G.S., &c., 12, Chester Street, Grosvenor Place. S.W.
Gardner, J. S., Esq., F.G.S., Park House, St. John's Wood Park. N.W.
Gardner, R., Esq., junr., Clive, Shrewsbury.
Gassiot, I. P., Esq., F.R.S., &c., Clapham. S.
Gatty, Charles Henry, Esq., F.G.S., Felbridge Park, East Grinstead.
Gaudry, Prof., F.C.G.S., Paris.
Geological Society of Manchester.
Geological Survey of Great Britain, Palæontological Department, Jermyn Street. S.W.
Geological Survey of Ireland.
Geologists' Association, University College. W.C.
Gibson, G. S., Esq., Saffron Walden.
Gibson, Thomas F., Esq., F.G.S., &c., Broadwater Down, Tunbridge Wells.
Glasgow Geological Society, Andersonian University, Glasgow.
Glen, D. C., Esq., 14, Annfield Place, Glasgow.
Gloucester Literary Society, Gloucester (by Dr. B. Wagbourn).
Godlee, Mrs., Whips Cross, Walthamstow. E.
Godwin-Austen, R. A. C., Esq., F.R.S., G.S., &c., *Local Secretary*, Shalford House, Guildford, Surrey.
Gough, Viscount, F.G.S., L.S., &c., Lough Cutra Castle, Gort, Galway, Ireland.
Gough, Thomas, Esq., *Local Secretary*, Kendal.
Gould, John, Esq., F.R.S., L.S., Z.S., &c., 26, Charlotte Street, Bedford Square. W.C.
Grant, James, Esq., Jun., 55, St. George's Road, Glasgow.
Gray, John, Esq., Lyttleton Terrace, Hagley, near Stourbridge.
Greenwell, G. C., Esq., Poynton, Stockport.
Griffith, Sir Richard, Bart., LL.D., F.R.S.E., G.S., &c., 2, Fitzwilliam Place, Dublin.
Grindrod, R. B., M.D., F.G.S., &c., *Local Secretary*, Townshend House, Great Malvern.
Grossart, Wm., Esq., Salsburgh, Holytown, Lanarkshire.
Grundy, Thomas, Esq., Beatlands, Sidmouth, Devon.
Guest, B., Esq., 26, Granville Park, Lewisham. S.E.

Guise, Sir W. V., Bart., F.G.S., &c., Elmore Court, near Gloucester.
Gunn, Rev. J., M.A., *Local Secretary,* 10, Cathedral Street, Norwich.

Hall, Hugh F., Esq., F.G.S., 17, Dale Street, Liverpool.
Hall, Townshend M., Esq., F.G.S., *Local Secretary,* Pilton Parsonage, Barnstaple.
Harford, Frederick, Esq., Ocean Marine Insurance Company, 2, Old Broad Street. E.C.
Harkness, Professor Robert, F.R.S., G.S., Queen's College, Cork.
Harmer, F. W., Esq., F.G.S., Heigham Grove, Norwich.
Harris, E., Esq., F.G.S., Rydal Villa, Longton Grove, Upper Sydenham. S.E.
Harrison, William, Esq., F.G.S., S.A., R.G.S., R.S.Ant., &c., *Local Secretary*, Samlesbury Hall, Preston, Lancashire; and Conservative Club, St. James's Street. S.W.
Hartley Institution, Southampton, per T. W. Shore, Esq., F.C.S., *Secretary.*
Haughton, Rev. Professor S., M.D., F.R.S., G.S., Fellow of Trinity College, Dublin.
Hawkes, Rev. Henry, B.A., F.L.S., &c., 2, St. Paul's Square, Southsea, Portsmouth.
Hawkins, B. Waterhouse, Esq., F.L.S., G.S., *Local Secretary,* New York.
Hawkins, Rev. H. S., Forest Lodge, Liphook, Hants.
Hawkshaw, J. Clarke, Esq., 25, Cornwall Gardens, South Kensington. W.
Haythornthwaite, William, Esq., Kirkby Lonsdale.
Hébert, Prof., F.M.G.S., Paris.
Heidelburg Library.
Hepburn, A. B., Esq., Smeaton, Preston Kirk. N.B.
Heywood, James, Esq., F.R.S., G.S., &c., 26, Palace Gardens, Bayswater Road. W.
Hicks, Henry, Esq., F.G.S., Heriot House, Hendon. N.W.
Higgins, E. T., Esq., 24, Bloomsbury Street. W.C.
Hindson, Isaac, Esq., Kirkby Lonsdale.
Hirst, John, Esq., jun., Dobcross, Saddleworth, near Manchester.
Hony, Rev. W. E., F.G.S., &c., Archdeacon of Sarum, Beverstock, near Salisbury.
Hopgood, James, Esq., Clapham Common. S.W.
Horen, Dr. F. Van, St. Trond, Belgium.
Host, M., Copenhagen.
Howchen, Rev. Walter, Newgate Street, Morpeth.
Howitt, Thomas, Esq., Queen Square, Lancaster.
Huddersfield Literary and Scientific Society.
Hudleston, W. H., Esq., 23, Cheyne Walk. S.W.
Hughes, T. M'K., Prof., F.G.S., &c., Cambridge.
Hudson, Robert, Esq., F.R.S., G.S., Clapham. S.W.
Hull, W. D., Esq., F.G.S., &c., Stanton Lodge, Tunbridge Wells.
Hunt, J., Esq., Milton of Campsie, Glasgow. N.B.
Hunter, J. R. S., LL.D., Daleville, Carluke. N.B.
Huxley, Professor T. H., LL.D., Ph.D., F.R.S., L.S., G.S., Museum of Practical Geology, Jermyn Street. S.W.

Ilott, James William, Esq., Beechfield, Bromley, Kent.
Ipswich Museum, Ipswich.

Jeffreys, J. Gwyn, LL.D., F.R.S., Tres. G.S., L.S., The Priory, Ware, Herts.
Jesson, Thomas, Esq., 3, Clarendon Terrace, Brighton.
Johnes, J., Esq., F.G.S., Dolancothy, Llandilo, Wales.
Jones, John, Esq., Saltburn by the Sea, Yorkshire.
Jones, Professor T. Rupert, F.R.S., G.S., &c., 5, College Terrace, York-town, Surrey.

Jordan, Swinfen, Esq., Cherith Lodge, Clifton Park, Bristol.
Jose, J. E. Esq., 1, Royal York Crescent, Clifton, Bristol.

King, W. P., Esq., Avonside, Clifton Down, Bristol.
Kinnaird, Lord, Rossie Priory, Inchture. N.B.
King's School, Library of, Sherborne.
Kingston, G. S., Esq., Grote Street, Adelaide, South Australia.
Knapp, Rev. John, St. John's Parsonage, Portsea, Portsmouth, Hants.
Krantz, Herr, Bonn.

Lawrance, John, Esq., F.G.S., Elton, Peterborough.
Leaf, C. J., Esq., F.G.S., Old Change, E.C.; and Cobham, Surrey.
Leckenby, John, Esq., F.G.S., *Local Secretary*, Scarborough.
Lee, Henry, Esq., F.L.S., G.S., The Waldrons, Croydon. S.
Lee, John Edward, Esq., F.G.S., Villa Syracuse, Torquay.
Leeds, C. E., Esq., M.A., Embury, Peterborough.
Leeds Library, Commercial Street, Leeds, Yorkshire.
Leicester Town Museum.
Leighton, W. H., Esq., 2, Merton Place, Turnham Green. W.
Leipzig, Museum of.
Lindsay, Charles, Esq., Ridge Park, Lanark. N.B.
Lingard, John R., Esq., 8, Booth Street, Piccadilly, Manchester.
Linn, James, Esq., Livingstone, by Midcalder. N.B.
Linnean Society, Burlington House, Piccadilly. W.
Lister, Arthur, Esq., Leytonstone. N.E.
Literary and Philosophical Society of Manchester.
Literary and Philosophical Society of Newcastle, Westgate Street, Newcastle-on-Tyne.
Literary and Philosophical Society of Sheffield.
Liveing, Professor G. D., M.A., The Pigthtle, Cambridge.
Liverpool Free Public Library.
Lloyd, J. H., Esq., 100, Lancaster Gate. W.
Lobley, J. L., Esq., F.G.S., 59, Clarendon Road, Kensington Park. W.
London Institution, Finsbury Circus. E.C.
Loriol, Mons. P. de, Céligny, Switzerland.
Lovèn, Professor S., Stockholm.
Lubbock, Sir John W., Bart., M.A., F.R.S., L.S., &c., 15, Lombard Street. E.C.
Ludlow Natural History Society.
Lyon, Bibliothèque de la Ville de.

McMurtrie, James, Esq., Radstock, Bath.
Mackenzie, J. W., Esq., 15, Hans Place. S.W.
Mackeson, Henry B., Esq., F.G.S., &c., Hythe, Kent.
Macmillan, Messrs., Cambridge.
Mac Moreland, Rev. J. P., The Manse, Minto, Hawick. N.B.
Madras Government Museum (per Messrs. Williams and Norgate).
Maggs, T. C., Esq., Medical Hall, Yeovil.
Major, Charles, Esq., Red Lion Wharf, Upper Thames Street. E.C.
Manchester Free Library.
Mann, C. S., Esq., F.G.S., Eltham, Kent. S.E.

Mansel-Pleydell, John, Esq., F.G.S., Longthorns, Blandford, Dorset.
Manzoni, Dr. Angelo, Ravenia.
Marburgh, University of.
Marshall, Reginald D., Esq., Cookridge Hall, Leeds.
Marsham, Hon. Robert, F.G.S., 5, Chesterfield Street, Mayfair. W.
Martin, Miss, Bredon's Norton, near Tewkesbury.
Mason, J. W., Esq., F.G.S., India Museum, Calcutta.
Mason, P. B., Esq., Burton-on-Trent.
Mason, Robert, Esq., 6, Albion Crescent, Downhill, Glasgow.
Mathews, W., Esq., F.G.S., *Local Secretary*, 49, Hanborne Road, Birmingham.
Maw, G., Esq., F.S.A., L.S., G.S., Benthall Hall, Broseley, Salop.
Meade, Rev. R. J., Castle Cary.
Merian, Professor Dr. Pierre, F.M.G.S., Directeur du Muséum, Basle.
Meryon, Edward, M.D., F.G.S., 14, Clarges Street. W.
Meyer, C. J. A., Esq., F.G.S., 8, Church Buildings, Clapham Common. S.W.
Milne-Edwards, Prof. H., F.M.G.S., Jardin des Plantes, Paris.
Mitchell, F. J., Esq., Llanbrechba Grange, Newport, Monmouthshire.
Mohr, M., Esq.
Moiser, H. R., Esq., F.G.S., Heworth Grange, York.
Molyneaux, W., Esq.
Monk, James, Esq., Aden Cottage, Durham.
Mons, Museum of, Belgium, per Prof. C. A Houzeau, Ryon, près Mons.
Moore, J. Carrick, Esq., M.A., F.R.S., G.S., &c., 113, Eaton Square. S.W.
Moore, Charles, Esq., F.G.S., 6, Cambridge Place, Widcome Hill, Bath.
Moore, Joseph, Esq., Brockwell House, Dulwich. S.E.
Morton, George Highfield, Esq., F.G.S., *Local Secretary*, 122, London Road, Liverpool.
Murdock, James Barclay, Esq., 33, Lynedoch Street, Glasgow.
Mure, T. M., Esq., Perceton-by-Irvine, Ayrshire. N.B.
Museum of Practical Geology, Jermyn Street. S.W.

Nantes, Musée d'Histoire Naturelle de.
Neale, Edward Vansittart, Esq., 12, Church Row, Hampstead. N.W.
Neilson, J., Esq., Jun., 824, Callowgate, Glasgow.
Newberry, Dr. John, School of Mines, Columbia College, New York.
Norfolk and Norwich Literary Institution, Norwich.
Norton, R. B., Esq., 3, Chesterfield Street, Mayfair, London. W.
Nottingham Literary and Philosophical Society, School of Art, Nottingham.
Nutt, D., Esq., Strand. W.C.

Oldham, Mrs., Hyde House, South Littleton, Evesham, Worcestershire.
Oñate, Countess of, Madrid.
Oswestry Naturalists' Field Club, Oswestry.
Ormerod, G. W., Esq., M.A., F.G.S., &c., Brookbank, Teignmouth.
Owen, Professor R., M.D., LL.D., C.B., F.R.S., L.S., G.S., &c., *Vice-President*, British Museum. W.C.
Owens College, Manchester.

Paine, Mrs. J. M., Farnham, Surrey.
Panter, Rev. J. Arthur, B.A., College House, Malvern.
Papillon, Rev. J., Rectory, Lexden, Colchester.

Parker, J., Esq., F.G.S., Turl Street, Oxford.
Parrott, J., Esq., Jolesfield Schools, West Grimstead, Horsham.
Pattison, S. R., Esq., F.G.S., 50, Lombard Street. E.C.
Paynter, Rev. Samuel, Stoke Hill, Guildford, Surrey.
Peabody Institution, America.
Pease, Thomas, Esq., F.G.S., Cote Bank, Westbury-on-Trym, Bristol.
Peckover, Algernon, Esq., F.L.S., Wisbeach.
Peek, Sir Henry W., Bart., M.P., Wimbledon House, Wimbledon, S.W.
Pengelly, William, Esq., F.R.S., G.S., *Local Secretary*, Torquay.
Penny, Rev. C. W., Wellington College, Wokingham.
Penruddocke, Charles, Esq., Compton Park, near Salisbury.
Perkins, Rev. R. B., Wootton-Underedge, Gloucestershire.
Philosophical Society of Glasgow.
Phear, Rev. George, F.G.S., Emmanuel College Lodge, Cambridge.
Phené, John S., LL.D., F.G.S., 32, Oakley Street, Chelsea. S.W.
Pictet, Mons. F. J., Professor of Zoology, Academy of Geneva.
Plant, James, Esq., *Local Secretary*, 40, West Terrace, West Street, Leicester.
Player, J. H., Esq., 208, Hagley Road, Birmingham.
Plymouth Institution, Library of.
Pomel, Mons., Oran.
Poynton, Rev. Francis, Rectory, Kelston, Bath.
Prestwich, Prof. Joseph, F.R.S., G.S., *Local Secretary*, Shoreham, Sevenoaks.
Portal, Wyndham S., Esq., Malshanger House, Basingstoke.
Powrie, James, Esq., F.G.S., Reswallie, Forfar.
Price, F. G. H., Esq., 25, Clarendon Gardens, Maida Hill, W.
Pryor, M. R., Esq., 12, Great Winchester Street. E.C.

Quaritch, B., Esq., Piccadilly. W.
Queen's College, Cork (by Messrs. Hodges and Smith).
Queen's College, Galway.
Queen's College, Oxford.

Radcliffe Library, Oxford.
Ramsay, Mrs. Wm., Rannagubzion, Blairgowrie.
Ramsay, Professor A. C., LL.D., F.R.S., G.S., &c., Museum Pract. Geology, Jermyn Street. S.W.
Ransome, Robert Charles, Esq., Ipswich.
Renevier, Mons. E., Professor of Geology, Academy of Lausanne, Switzerland.
Ricketts, Charles, M.D., F.G.S., 22, Argyle Street, Birkenhead.
Rigby, G., Esq., 12, Ormerod Street, Burnley.
Rigby, S., Esq., Bruche Hall, near Warrington.
Ripon Scientific Society.
Roberts, Isaac, Esq., F.G.S., 26, Rock Park, Rock Ferry, Birkenhead, Cheshire.
Robertson, D., Esq., F.G.S., 108, Woodlands Road, Glasgow.
Robertson, Edw. H., Esq., 31, Tressillion Road, Upper Lewisham Road, London. S.E.
Robbins, George, Esq., F.G.S., 9, Royal Crescent, Bath.
Robinson, George, Esq., 8, Broad Street, Halifax.
Roemer, Professor F., University of Breslau, Silesia.
Rofe, John, Esq., F.G.S., &c., 6, Crosbie Terrace, Leamington.
Roper, F. C. S., Esq., F.G.S., L.S., Palgrave House, Eastbourne.
Rothery, H. C., Esq., M.A., F.L.S., 94, Gloucester Terrace, Hyde Park. W.

Rothery, Charles W., Esq., Little Thorpe Villa, near Ripon.
Royal Artillery Institution, Woolwich. S.E.
Royal College of Science for Ireland, Stephen's Green, Dublin.
Royal College of Surgeons, Lincoln's Inn Fields. W.C
Royal Dublin Society, Dublin.
Royal Geological Society of Cornwall, Penzance.
Royal Institution of Cornwall, Truro.
Royal Institution of Great Britain, Albemarle Street. W.
Royal Institution, Liverpool.
Royal Institution of South Wales, Swansea.
Royal Irish Academy, 19, Dawson Street, Dublin.
Royal Society of Edinburgh.
Royal Society of London, Burlington House. W.
Royal Society of Tasmania.
Rudd, Rev. Leonard H., M.A., Kempsey, Worcester.
Rutter, John, Esq., Ilminster.
Rylands, T. G., Esq., F.L.S., G.S., Highfields, Thelwall, near Warrington.

Sabine, General Sir Edward, R.E., F.R.S., L.S., &c., 13, Ashley Place, Westminster. S.W.
St. John's College, Cambridge.
St. Peter's College, Cambridge.
Salford Borough Royal Museum and Library, Peel Park.
Salt, S., Esq., Gateside, Silecroft, Cumberland.
Sanders, Gilbert, Esq., M.R.I.A., &c., Brockley-on-the-Hill, Monkstown, Co. Dublin.
Sanders, W., Esq., F.R.S., G.S., &c., *Local Secretary*, Hanbury Lodge, The Avenue, Clifton, Bristol.
Sanford, W. A., Esq., F.G.S., Nynehead Court, Wellington, Somerset.
Saul, G. T., Esq., F.Z.S., Bow Lodge, Bow Road. E.
Saunders, James Ebenezer, Esq., F.L.S., G.S., 9, Finsbury Circus. E.C.
Savy, Mons. F., *Local Secretary*, 77, Boulevart, St. Germain, Paris.
Scarborough Philosophical Society.
Scientific Club, 7, Savile Row. W.
Seguenza, Prof., Messina.
Sells, T. J., Esq., F.G.S., Guildford.
Severs, J., Esq., Airthwaite, Kendal.
Sharman, George, Esq., St. Leonard's Villas, West End Lane, Kilburn. N.W.
Sharp, John, Esq., F.G.S., *Local Secretary*, Culverden Hill, Tunbridge Wells, Kent.
Sharp, Samuel, Esq., F.G.S., S.A., Dallington Hall, Northampton.
Sidney Sussex College Library, Cambridge.
Simpson, J. B., Esq., Hedgefield House, Blaydon-on-Tyne.
Skaife, John, Esq., 6, Union Street, Blackburn.
Sladen, W. P., Esq., Ezley House, Halifax.
Sloper, G. E., Esq., Devizes.
Smith, Rev. Charles Lesingham, Little Canfield Rectory, near Dunmow.
Smith, J., Esq., Stobbs, Kilwinning.
Smith, Captain Robert, 65, Frankford Avenue, Rathgar, Dublin.
Smith, Rev. Urban, Stoney Middleton.
Smithe, J. D., Esq., C.E., F.G.S., Madhopoor, Punjâb (by Messrs. Smith, Elder, and Co.).
Somersetshire Archæological and Natural History Society, Museum, Taunton.

Sommerville, J., Esq., 7, Westbury Street, Glasgow.
Sopwith, T., Esq. F.R.S., G.S., 103, Victoria Street. S.W.
Society Isis, Dresden (per Dr. H. B. Geinitz, F.M.G.S.).
Spencer, John, Esq., Rock Terrace, Crawshawbooth, Manchester.
Spicer, Henry, Esq., jun., F.G.S., 19, New Bridge Street, Blackfriars. E.C.
Spink, J., Esq., Drax, Selby.
Spragge, W. Kennaway, Esq., the Quarry, Paignton, South Devon.
Stebbing, Rev. T. R. R., M.A., Tor Crest, Hall, Torquay.
Stephens, Darell, Esq., St. Stephens, Ridgeway, Plympton, Devon.
Stevens, C., Esq.
Stewart, Mrs. John, 7, Grosvenor Crescent, Edinburgh.
Stewart, S. A., Esq., 6, North Street, Belfast.
Stobart, W. C., Esq., Etherley Lodge, Darlington.
Stockholm Academy of.
Stoddart, W. W., Esq., F.G.S., 9, North Street, Bristol.
Studer, Herr B., For.M.G.S., Professor of Geology, Berne.
Sunderland Corporation Museum.
Sunderland Subscription Library.
Swayne, H. J. F., Esq., The Island, Wilton, Wilts.

Tawney, E. B., Esq., F.G.S., 16, Royal York Crescent, Clifton, Bristol.
Taylor, John, Esq., Earsdon, Newcastle-on-Tyne.
Taylor, S. Watson, Esq., Erlestoke Park, Devizes.
Tennant, Professor Jas., F.G.S., &c., 149, Strand. W.C. (*Two Copies.*)
Thomas, Capt. F. W. L., R.N., Rose Park, Trinity, near Edinburgh.
Thomson, James, Esq., F.G.S., *Local Secretary*, 176, Eglinton Street, Glasgow.
Thompson, Miss S., Stamford.
Thomson, Professor Wyville, LL.D., F.G.S., Edinburgh.
Thorpe, W. G., Esq., F.G.S., Gloucester House, Larkhall Rise, S.W., and Barton House, Ipplepen, Devon.
Torquay Natural History Society.
Trautschold, Dr., Moscow.
Traquair, Professor R. H., M.D., Royal College of Science for Ireland, Stephens Green, Dublin.
Trevelyan, Sir W. C., Bart., F.G.S., Wellington, Newcastle-on-Tyne; and Athenæum Club. S.W.
Trinity College, Cambridge.
Twamley, Charles, Esq., F.G.S., 11, Regent's Park Road. N.W.
Tyler, Capt. Chas., F.L.S., G.S., 317, Holloway Road, Holloway. N.
Tylor, Alfred, Esq., F.L.S., G.S., Warwick Lane, Newgate Street. E.C.

University of Edinburgh.
University of Glasgow.
University Library, Aberdeen.
University Library, Leipzig.
University Library, St. Andrew's.

Valpy, R. H., Esq.
Verneuil, Mons. Edouard de, Mem. de l'Instit., F.M.G.S., 76, Rue de Varenne, Paris.
Vernon Park Museum, Stockport.
Vicary, William, Esq., F.G.S., The Priory, Colleton Crescent, Exeter.

Wall, Geo. P., Esq., F.G.S., 3, Victoria Street, Broomhill Park, near Sheffield.
Walmstedt, Dr. L. P., Professor of Mineralogy, Upsala.
Walton, William, Esq., 11, Paragon, Blackheath. S.E.
Ward, Henry, Esq., F.G.S., Rodbaston, Penkridge.
Wardle, Thos., Esq., F.G.S., St. Edward Street, Leek.
Waring, Samuel Long, Esq., F.G.S., The Oaks, Norwood, Surrey. S.
Warrington Museum and Library.
Warwickshire Natural History Society, Warwick.
Watson, Rev. R. B., F.G.S., 19, Chalmers Street, Edinburgh.
West, G. Herbert, Esq., B.A., F.G.S., Woodcote, Bournemouth, Hants.
Westermann, Messrs., New York.
Wetherell, N. T., Esq., F.G.S., &c., Highgate. N.
White, Alfred, Esq., F.L.S., West Drayton.
Willaume, T. B. T., Esq., jun., 9, Queensborough Terrace, Kensington Gardens. W.
Willcock, J. W., Esq., Cliebion, Clemmaes, Montgomeryshire.
Williams and Norgate, Messrs., Henrietta Street, Covent Garden. W.C.
Willis and Sotheran, Messrs., Strand. W.C.
Wilson, J. M., Esq., B.A., F.G.S., Rugby.
Wiltshire, Rev. Thomas, M.A., F.L.S., Sec. G.S., &c., *Honorary Secretary*, 25, Granville Park, Lewisham, Kent. S.E.
Winstone, Benjamin, M.D., 53, Russell Square. W.C.
Witts, Rev. E. F., F.G.S., Rectory, Upper Slaughter, near Stow-on-the-Wold.
Winchester College Natural History Society.
Winwood, Rev. Henry H., F.G.S., *Local Secretary*, 4, Cavendish Crescent, Bath.
Wollaston, G. H., Esq., M.A., F.G.S., 117, Pembroke Road, Clifton, Bristol.
Wolley-Dod, Rev. Charles, Eton College.
Wood, Edward, Esq., F.G.S., R.S.L., &c., *Local Secretary*, Richmond, Yorkshire.
Wood, Henry, Esq., 10, Cleveland Square, Bayswater. W.
Wood, Rev. Henry H., F.G.S., Holwell Rectory, Sherborne, Dorset.
Wood, Rev. J. E. Tenison, F.G.S., Penola, South Australia.
Wood, Rev. Matthew T., The Lodge, Evesham.
Wood, S. V., Esq., F.G.S., &c., *Treasurer*, Beacon Hill House, Martlesham, Woodbridge, Suffolk.
Woodall, Major J. W., M.A., F.G.S., &c., St. Nicholas House, Scarborough.
Woodd, A. B., Esq., Woodlands, Hampstead. N.W.
Woodd, C. H. L., Esq., F.G.S., &c., Roslyn, Hampstead. N.W.
Woodward, Charles, Esq., F.R.S., 10, Compton Terrace, Islington. N.
Woodward, Henry, Esq., F.R.S., G.S., Z.S., British Museum. W.C.
Woodwardian Museum, Cambridge.
Worcestershire Natural History Society, Foregate, Worcester.
Wright, F. Beresford, Esq., Aldercar Hill, Langley Mill, Nottingham.
Wright, Joseph, Esq., F.G.S., 1, Donegall Street, Belfast.
Wright, Thomas, M.D., F.R.S.E., G.S., *Vice-President*, St. Margaret's Terrace, Cheltenham.
Wrightman, W. H., Esq., Minster Buildings, Church Street, Liverpool.
Wurzburg, the Royal University Library of.

Yorkshire Philosophical Society, York.

Zoological Society of London, 11, Hanover Square. W.

CATALOGUE OF WORKS

ALREADY PUBLISHED BY

THE PALÆONTOGRAPHICAL SOCIETY:

Showing the ORDER *of publication; the* YEARS *during which the Society has been in operation; and the* CONTENTS *of each yearly Volume.*

Vol. I. Issued for the Year 1847		The Crag Mollusca, Part I, Univalves, by Mr. S. V. Wood, 21 plates.
„ II. „	1848	The Reptilia of the London Clay, Part I, Chelonia, &c., by Profs. Owen and Bell, 38 plates. The Eocene Mollusca, Part I, Cephalopoda, by Mr. F. E. Edwards, 9 plates.
„ III.* „	1849	The Entomostraca of the Cretaceous Formations, by Mr. T. R. Jones, 7 plates. The Permian Fossils, by Prof. Wm. King, 29 plates. The Reptilia of the London Clay, Part II, Crocodilia and Ophidia, &c., by Prof. Owen, 18 plates. The Fossil Corals, Part I, Crag, London Clay, Cretaceous, by Messrs. Milne Edwards and Jules Haime, 11 plates.
„ IV. „	1850	The Crag Mollusca, Part II, No. 1, by Mr. S. V. Wood, 12 plates. The Mollusca of the Great Oolite, Part I, Univalves, by Messrs. Morris and Lycett, 15 plates. The Fossil Brachiopoda, Part III, No. 1, Oolitic and Liassic, by Mr. Davidson, 13 plates.
„ V. „	1851	The Reptilia of the Cretaceous Formations, by Prof. Owen, 39 plates. The Fossil Corals, Part II, Oolitic, by Messrs. Milne Edwards and Jules Haime, 19 plates. The Fossil Lepadidæ, by Mr. Charles Darwin, 5 plates.
„ VI. „	1852	The Fossil Corals, Part III, Permian and Mountain-limestone, by Messrs. Milne Edwards and Jules Haime, 16 plates. The Fossil Brachiopoda, Part I, Tertiary, by Mr. Davidson, 2 plates. The Fossil Brachiopoda, Part II, No. 1, Cretaceous, by Mr. Davidson, 5 plates. The Fossil Brachiopoda, Part III, No. 2, Oolitic and Liassic, by Mr. Davidson, 5 plates. The Eocene Mollusca, Part II, Pulmonata, by Mr. F. E. Edwards, 6 plates. The Radiaria of the Crag, London Clay, &c., by Prof. E. Forbes, 4 plates.

* The volume for the year 1849 consists of two separate portions, each of which is stitched in a paper cover, on which are printed the dates 1848, 1849, and 1850.

CATALOGUE OF WORKS—Continued.

Vol. VII.	Issued for the Year 1853	The Fossil Corals, Part IV, Devonian, by Messrs. Milne Edwards and Jules Haime, 10 plates. The Fossil Brachiopoda, Introduction to Vol. I, by Mr. Davidson, 9 plates. The Mollusca of the Chalk, Part I, Cephalopoda, by Mr. D. Sharpe, 10 plates. The Mollusca of the Great Oolite, Part II, Bivalves, by Messrs. Morris and Lycett, 8 plates. The Mollusca of the Crag, Part II, No. 2, Bivalves, by Mr. S. V. Wood, 8 plates. The Reptilia of the Wealden Formations, Part I, Chelonia, by Prof. Owen, 9 plates.
„ VIII.	„ *1854	The Fossil Brachiopoda, Part II, No. 2, Cretaceous, by Mr. Davidson, 8 plates. The Reptilia of the Wealden Formations, Part II, Dinosauria, by Prof. Owen, 20 plates. The Mollusca of the Great Oolite, Part III, Bivalves, by Messrs. Morris and Lycett, 7 plates. The Fossil Corals, Part V, Silurian, by Messrs. Milne Edwards and Jules Haime, 16 plates. The Fossil Balanidæ and Verrucidæ, by Mr. Charles Darwin, 2 plates. The Mollusca of the Chalk, Part II, Cephalopoda, by Mr. D. Sharpe, 6 plates. The Eocene Mollusca, Part III, No. 1, Prosobranchiata, by Mr. F. E. Edwards, 8 plates.
„ IX.	„ †1855	The Mollusca of the Crag, Part II, No. 3, Bivalves, by Mr. S. V. Wood, 11 plates. The Reptilia of the Wealden Formations, Part III, by Prof. Owen, 12 plates. The Eocene Mollusca, Part III, No. 2, Prosobranchiata, continued, by Mr. F. E. Edwards, 4 plates. The Mollusca of the Chalk, Part III, Cephalopoda, by Mr. D. Sharpe, 11 plates. The Tertiary Entomostraca, by Mr. T. R. Jones, 6 plates. The Fossil Echinodermata, Part I, Oolitic, by Dr. Wright, 10 plates.
„ X.	„ 1856	The Fossil Echinodermata, Part II, Oolitic, by Dr. Wright, 12 plates. The Fossil Crustacea, Part I, London Clay, by Prof. Bell, 11 plates. The Fossil Brachiopoda, Part IV, Permian, by Mr. Davidson, 4 plates. The Fossil Brachiopoda, Part V, No. 1, Carboniferous, by Mr. Davidson, 8 plates. The Reptilia of the Wealden Formations, Part IV (Supplement No. 1), by Prof. Owen, 11 plates. The Reptilia of the London Clay (Supplement), by Prof. Owen, 2 plates.
„ XI.	„ 1857	The Fossil Echinodermata, Part III, Oolitic, by Dr. Wright, 14 plates. The Fossil Brachiopoda, Part V, No. 2, Carboniferous, by Mr. Davidson, 8 plates. The Reptilia of the Cretaceous Formations (Supplement 1), by Prof. Owen, 4 plates. The Reptilia of the Wealden Formations (Supplement No. 2), by Prof. Owen, 8 plates. The Polyzoa of the Crag, by Prof. Busk, 22 plates.
„ XII.	„ 1858	The Fossil Echinodermata, Part IV, Oolitic, by Dr. Wright, 7 plates. The Eocene Mollusca, Part III, No. 3, Prosobranchiata continued, by Mr. F. E. Edwards, 6 plates. The Reptilia of the Cretaceous Formations (Supplements No. 2, No. 3), by Prof. Owen, 7 plates. The Reptilia of the Purbeck Limestones, by Prof. Owen, 1 plate. The Fossil Brachiopoda, Part V, No. 3, Carboniferous, by Mr. Davidson, 10 plates.
„ XIII.	„ 1859	The Fossil Brachiopoda, Part V, No. 4, Carboniferous, by Mr. Davidson, 20 plates. The Reptilia of the Oolitic Formations, No. 1, Lower Lias, by Prof. Owen, 6 plates. The Reptilia of the Kimmeridge Clay, No. 1, by Prof. Owen, 1 plate. The Eocene Mollusca, Part IV, No. 1, Bivalves, by Mr. S. V. Wood, 13 plates.

* This Vol. is marked on the outside 1855.

† This Vol. is marked on the outside 1856.

CATALOGUE OF WORKS—Continued.

Vol. XIV. Issued for the Year	1860	The Fossil Brachiopoda, Part V, No. 5, Carboniferous, by Mr. Davidson, 8 plates. The Reptilia of the Oolitic Formation, No. 2, Lower Lias, by Prof. Owen, 11 plates. The Reptilia of the Kimmeridge Clay, No. 2, by Prof. Owen, 1 plate. The Fossil Estheriæ, by Prof. Rupert Jones, 5 plates. The Fossil Crustacea, Part II, Gault and Greensand, by Prof. Bell, 11 plates.
„ XV. „	1861	The Fossil Echinodermata, Vol. II, Part I (Oolitic Asteroidea), by Dr. Wright, 13 plates. Supplement to the Great Oolite Mollusca, by Dr. Lycett, 15 plates.
„ XVI. „	1862	The Fossil Echinodermata, Cretaceous, Vol. I, Part I, by Dr. Wright, 11 plates. The Trilobites of the Silurian, Devonian, &c., Formations, Part I, by Mr. J. W. Salter, 6 plates. The Fossil Brachiopoda, Part VI, No. 1, Devonian, by Mr. Davidson, 9 plates. The Eocene Mollusca, Part IV, No. 2, Bivalves, by Mr. S. V. Wood, 7 plates. The Reptilia of the Cretaceous and Wealden Formations (Supplements), by Prof. Owen, 10 plates.
„ XVII. „	1863	The Trilobites of the Silurian, Devonian, &c., Formations, Part II, by Mr. J. W. Salter, 8 plates. The Fossil Brachiopoda, Part VI, No. 2, Devonian, by Mr. Davidson, 11 plates. The Belemnitidæ, Part I, Introduction, by Prof. Phillips. The Reptilia of the Liassic Formations, Part I, by Prof. Owen, 16 plates.
„ XVIII. „	1864	The Fossil Echinodermata, Vol. II, Part II (Liassic Ophiuroidea), by Dr. Wright, 6 plates. The Trilobites of the Silurian, Devonian, &c., Formations, Part III, by Mr. J. W. Salter, 11 plates. The Belemnitidæ, Part II, Liassic Belemnites, by Prof. Phillips, 7 plates. The Pleistocene Mammalia, Part I, Introduction, Felis spelæa, by Messrs. W. Boyd Dawkins and W. A. Sanford, 5 plates. Title-pages, &c., to the Monographs on the Reptilia of the London Clay, Cretaceous, and Wealden Formations.
„ XIX.* „	1865	The Crag Foraminifera, Part I, No. 1, by Messrs. T. Rupert Jones, W. K. Parker, and H. B. Brady, 4 plates. Supplement to the Fossil Corals, Part I, Tertiary, by Dr. Duncan, 10 plates. The Fossil Merostomata, Part I, Pterygotus, by Mr. H. Woodward, 9 plates. The Fossil Brachiopoda, Part VII, No. 1, Silurian, by Mr. Davidson, 12 plates.
„ XX.* „	1866	Supplement to the Fossil Corals, Part IV, No. 1, Liassic, by Dr. Duncan, 11 plates. The Trilobites of the Silurian, Devonian, &c., Formations, Part IV (Silurian), by Mr. J. W. Salter, 6 plates. The Fossil Brachiopoda, Part VII, No. 2, Silurian, by Mr. Davidson, 10 plates. The Belemnitidæ, Part III, Liassic Belemnites, by Prof. Phillips, 13 plates.
„ XXI.* „	1867	Flora of Carboniferous Strata, Part I, by Mr. E. W. Binney, 6 plates. Supplement to the Fossil Corals, Part IV, No. 2, Liassic, by Dr. Duncan, 6 plates. The Fossil Echinodermata, Cretaceous, Vol. I, Part II, by Dr. Wright, 14 plates. The Fishes of the Old Red Sandstone, Part I, by Messrs. J. Powrie and E. Ray Lankester, 5 plates. The Pleistocene Mammalia, Part II, Felis spelæa, continued, by Messrs. W. Boyd Dawkins and W. A. Sanford, 14 plates.

* These Volumes are issued in two forms of binding; first, with all the Monographs stitched together and enclosed in one cover; secondly, with each of the Monographs separate, and the whole of the separate parts placed in an envelope. The previous volumes are not in separate parts.

CATALOGUE OF WORKS—Continued.

Vol. XXII.* Issued for the Year	1868	Supplement to the Fossil Corals, Part II, No. 1, Cretaceous, by Dr. Duncan, 9 plates. The Fossil Merostomata, Part II, Pterygotus, by Mr. H. Woodward, 6 plates. The Fossil Brachiopoda, Part VII, No. 3, Silurian, by Mr. Davidson, 15 plates. The Belemnitidæ, Part IV, Liassic and Oolitic Belemnites, by Prof. Phillips, 7 plates. The Reptilia of the Kimmeridge Clay, No. 3, by Prof. Owen, 4 plates. The Pleistocene Mammalia, Part III, Felis spelæa, concluded, with F. lynx, by Messrs. W. Boyd Dawkins and W. A. Sanford, 6 plates.
„ XXIII.* „	1869	Supplement to the Fossil Corals, Part II, No. 2, Cretaceous, by Dr. Duncan, 6 plates. The Fossil Echinodermata, Cretaceous, Vol. I, Part III, by Dr. Wright, 10 plates. The Belemnitidæ, Part V, Oxford Clay, &c., Belemnites, by Prof. Phillips, 9 plates. The Fishes of the Old Red Sandstone, Part I (concluded), by Messrs. J. Powrie and E. Ray Lankester, 9 plates. The Reptilia of the Liassic Formations, Part II, by Prof. Owen, 4 plates. The Crag Cetacea, No. 1, by Prof. Owen, 5 plates.
„ XXIV.* „	1870	The Flora of the Carboniferous Strata, Part II, by Mr. E. W. Binney, 6 plates. The Fossil Echinodermata, Cretaceous, Vol. I, Part IV, by Dr. Wright, 10 plates. The Fossil Brachiopoda, Part VII, No. 4, Silurian, by Mr. Davidson, 13 plates. The Eocene Mollusca, Part IV, No. 3, Bivalves, by Mr. S. V. Wood, 5 plates. The Fossil Mammalia of the Mesozoic Formations, by Prof. Owen, 4 plates.
„ XXV.* „	1871	The Flora of the Carboniferous Strata, Part III, by Mr. E. W. Binney, 6 plates. The Fossil Merostomata, Part III, Pterygotus and Slimonia, by Mr. H. Woodward, 5 plates. Supplement to the Crag Mollusca, Part I (Univalves), by Mr. S. V. Wood, with an Introduction on the Crag District, by Messrs. S. V. Wood, jun., and F. W. Harmer, 7 plates and map. Supplement to the Reptilia of the Wealden (Iguanodon), No. IV, by Prof. Owen, 3 plates The Pleistocene Mammalia, Part IV, Felis pardus, &c., by Messrs W. Boyd Dawkins and W. A. Sanford, 2 plates. The Pleistocene Mammalia, Part V, Ovibos moschatus, by Mr. W. Boyd Dawkins, 5 plates.
„ XXVI* „	1872	Supplement to the Fossil Corals, Part III (Oolitic), by Prof. Duncan, with an Index to the Tertiary and Secondary Species, 7 plates. The Fossil Echinodermata, Cretaceous, Vol. I, Part V, by Dr. Wright, 5 plates. The Fossil Merostomata, Part IV (Stylonurus, Eurypterus, Hemiaspis), by Mr. H. Woodward, 10 plates. The Fossil Trigoniæ, No. I, by Dr. Lycett, 9 plates.
„ XXVII* „	1873	The Fossil Echinodermata, Cretaceous, Vol I, Part VI, by Dr. Wright, 8 plates. Supplement to the Fossil Brachiopoda, Part I (Tertiary and Cretaceous), by Mr. Davidson, 8 plates. Supplement to the Crag Mollusca, Part II (Bivalves), by Mr. S. V. Wood, 5 plates. Supplement to the Reptilia of the Wealden (Iguanodon), No. V, by Prof. Owen, 2 plates. Supplement to the Reptilia of the Wealden (Hylæochampsa) No. VI, by Prof. Owen. The Fossil Reptilia of the Mesozoic Formations, Part I, by Prof. Owen, 2 plates.
„ XXVIII* „	1874	The Post-Tertiary Entomostraca, by Mr. G. S. Brady, Rev. H. W. Crosskey, and Mr. D. Robertson, 16 plates. The Carboniferous Entomostraca, Part I (Cypridinadæ), by Prof. T. Rupert Jones and Messrs. J. W. Kirkby and G. S. Brady, 5 plates. The Fossil Trigoniæ No. II, by Dr. Lycett, 10 plates.
„ XXIX* „	1875	The Flora of the Carboniferous Strata, Part IV, by Mr. E. W. Binney, 6 plates. The Fossil Echinodermata, Cretaceous, Vol. I, Part VII, by Dr. Wright, 10 plates. The Fossil Trigoniæ, No. III, by Dr. Lycett, 8 plates. The Fossil Reptilia of the Mesozoic Formations, Part II, by Professor Owen, 20 plates.

* These Volumes are issued in two forms of binding; first, with all the Monographs stitched together and enclosed in cover; secondly, with each of the Monographs separate, and the whole of the separate parts placed in an envelope.

LIST OF MONOGRAPHS

Completed, in course of Publication, and in Preparation.

MONOGRAPHS which have been COMPLETED :—

The Tertiary, Cretaceous, Oolitic, Devonian, and Silurian Corals, by MM. Milne Edwards and J. Haime.
The Polyzoa of the Crag, by Mr. G. Busk.
The Tertiary Echinodermata, by Professor Forbes.
The Fossil Cirripedes, by Mr. C. Darwin.
The Post-Tertiary Entomostraca, by Mr. G. S. Brady, the Rev. H. W. Crosskey, and Mr. D. Robertson.
The Tertiary Entomostraca, by Prof. T. Rupert Jones.
The Cretaceous Entomostraca, by Prof. T. Rupert Jones.
The Fossil Estheriæ, by Prof. T. Rupert Jones.
The Tertiary, Cretaceous, Oolitic, Liassic, Permian, Carboniferous, Devonian, and Silurian Brachiopoda, by Mr. T. Davidson.
The Mollusca of the Crag, by Mr. S. V. Wood.
Supplement to the Crag Mollusca, by Mr. S. V. Wood.
The Great Oolite Mollusca, by Professor Morris and Mr. J. Lycett.
The Cretaceous (Upper) Cephalopoda, by Mr. D. Sharpe.
The Fossils of the Permian Formation, by Professor King.
The Reptilia of the London Clay (and of the Bracklesham and other Tertiary Beds), by Professors Owen and Bell.
The Reptilia of the Cretaceous, Wealden, and Purbeck Formations, by Professor Owen.
The Fossil Mammalia of the Mesozoic Formations, by Professor Owen.

MONOGRAPHS in course of PUBLICATION :*—

The Flora of the Carboniferous Formation, by Mr. E. W. Binney.
The Crag Foraminifera, by Messrs. T. Rupert Jones, W. K. Parker, and H. B. Brady.
Supplement to the Fossil Corals, by Dr. Duncan.
The Echinodermata of the Oolitic and Cretaceous Formations, by Dr. Wright.
The Carboniferous Entomostraca, by Messrs. T. Rupert Jones, J. W. Kirkby, and G. S. Brady.
The Fossil Merostomata, by Mr. H. Woodward.

* Members having specimens which might assist the authors in preparing their respective Monographs are requested to communicate in the first instance with the Honorary Secretary.

MONOGRAPHS in course of PUBLICATION—*Continued.*

The Trilobites of the Mountain-Limestone, Devonian, and Silurian Formations, by Mr. J. W. Salter.*
The Malacostracous Crustacea, by Professor Bell.
Supplement to the Fossil Brachiopoda, by Mr. T. Davidson.
The Trigoniæ, by Dr. Lycett.
The Eocene Mollusca, by Mr. S. V. Wood.
The Belemnites, by Professor Phillips.†
The Fishes of the Old Red Sandstone, by Messrs. J. Powrie and E. Ray Lankester, and Professor Traquair.
The Reptilia of the Wealden Formation (Supplements), by Professor Owen.
The Reptilia of the Kimmeridge Clay, by Professor Owen.
The Reptilia of the Liassic Formations, by Professor Owen.
The Reptilia of the Mesozoic Formations, by Professor Owen.
The Pleistocene Mammalia, by Messrs. Boyd Dawkins and W. A. Sanford.
The Cetacea of the Crag, by Professor Owen.

* Unfinished through the death of the Author, but will be continued by Mr. H. Woodward.
† Unfinished through the death of the Author, but will be continued by Mr. R. Etheridge.

MONOGRAPHS which are in course of PREPARATION :‡—

The Cretaceous Foraminifera, by Messrs. T. Rupert Jones, W. K. Parker, and H. B. Brady.
The Foraminifera of the Lias, by Mr. H. B. Brady.
The Foraminifera of the Carboniferous and Permian Formations, by Mr. H. B. Brady.
The Graptolites, by Professor Wyville Thomson.
The Polyzoa of the Chalk Formation, by Mr. G. Busk.
The Palæozoic Polyzoa, by Dr. Duncan.
The Crinoidea, by Professor Wyville Thomson.
The Wealden, Purbeck, and Jurassic Entomostraca, by Messrs. T. Rupert Jones and G. S. Brady.
The Post-Tertiary Mollusca, by Mr. J. Gwyn Jeffreys.
The Cretaceous Mollusca (exclusive of the Brachiopoda), by the Rev. T. Wiltshire.
The Purbeck Mollusca, by Mr. R. Etheridge.
The Inferior Oolite Mollusca, by Mr. R. Etheridge.
The Rhætic Mollusca, by Mr. R. Etheridge.
The Liassic Gasteropoda, by Mr. Ralph Tate.
The Ammonites of the Lias, by Dr. Wright.
The Ganoid Fishes, by Mr. L. C. Miall.

---

‡ Members having specimens which might assist the authors in preparing their respective Monographs are requested to communicate in the first instance with the Honorary Secretary.

Dates of the Issue of the Yearly Volumes of the Palæontographical Society.

The Volume for	1847	was	issued	to the	Members,	March, 1848.
,,	1848	,,	,,		,,	July, 1849.
,,	1849	,,	,,		,,	August, 1850.
,,	1850	,,	,,		,,	June, 1851.
,,	1851	,,	,,		,,	June, 1851.
,,	1852	,,	,,		,,	August, 1852.
,,	1853	,,	,,		,,	December, 1853.
,,	1854	,,	,,		,,	May, 1855.
,,	1855	,,	,,		,,	February, 1857.
,,	1856	,,	,,		,,	April, 1858.
,,	1857	,,	,,		,,	November, 1859.
,,	1858	,,	,,		,,	March, 1861.
,,	1859	,,	,,		,,	December, 1861.
,,	1860	,,	,,		,,	May, 1863.
,,	1861	,,	,,		,,	May, 1863.
,,	1862	,,	,,		,,	August, 1864.
,,	1863	,,	,,		,,	June, 1865.
,,	1864	,,	,,		,,	April, 1866.
,,	1865	,,	,,		,,	December, 1866.
,,	1866	,,	,,		,,	June, 1867.
,,	1867	,,	,,		,,	June, 1868.
,,	1868	,,	,,		,,	February, 1869.
,,	1869	,,	,,		,,	January, 1870.
,,	1870	,,	,,		,,	January, 1871.
,,	1871	,,	,,		,,	June, 1872.
,,	1872	,,	,,		,,	October, 1872.
,,	1873	,,	,,		,,	February, 1874.
,,	1874	,,	,,		,,	July, 1874.
,,	1875	,,	,,		,,	December, 1875.

SUMMARY OF THE MONOGRAPHS ISSUED TO THE MEMBERS (*up to* DECEMBER, 1875): *showing in the* FIRST *column whether each Monograph hitherto published be* complete, *or in the* course of completion; *in the* SECOND *column, the yearly volumes which contain each particular Monograph (as a guide to binding the same); and in the* FOURTH *and following columns, the number of pages, plates, figures, and species described in the different Monographs.*

I. SUBJECT OF MONOGRAPH.	II. Dates of the Years *for which* the volume containing the Monograph was issued.	III *m.* Dates of the Years *in which* the Monograph was published.	IV. No. of Pages of Letterpress in each Monograph.	V. No. of Plates in each Monograph.	VI. No. of Lithographed Figures and of Woodcuts.	VII. No. of Species described in the Text.
The Flora of the Carboniferous Strata, by Mr. E. W. Binney, in course of completion	1867, 1870, 1871, 1875	1868, 1871, 1872, 1875	147	24	141	16
The Crag Foraminifera, by Messrs. T. Rupert Jones, W. K. Parker, and H. B. Brady, in course of completion	1865	1866	78	4	211	43
Tertiary, Cretaceous, Oolitic, Devonian, and Silurian Corals, by MM. Milne-Edwards and J. Haime, *complete* (*k*)	1849, 1851, 1852, 1853, 1854	1850, 1851, 1852, 1853, 1855	406	72	800	319*g*
Supplement to the Fossil Corals, by Prof. Duncan, in course of completion	1865, 1866, 1867, 1868, 1869, 1872	1866, 1867, 1868, 1869, 1870, 1872	232	49	797	149
The Polyzoa of the Crag, by Mr. G. Busk, *complete*	1857	1859	145	22	641	122
The Tertiary Echinodermata, by Prof. Forbes, *complete*	1852	1852	39	4	144	44
The Oolitic Echinodermata, by Dr. Wright. Vol. I, *complete* (*l*)	1855, 1856, 1857, 1858	1857, 1858, 1859, 1861	474	43	724	109*h*
" " Vol. II, in course of completion	1861, 1864	1863, 1866	154	19	218	29
The Cretaceous Echinodermata, by Dr. Wright. Vol. I, in course of completion	1862, 1867, 1869, 1870, 1872, 1873, 1875	1864, 1868, 1870, 1871, 1872, 1874, 1875	264	68	892	82
The Fossil Cirripedes, by Mr. C. Darwin, *complete*	1851, 1854, 1858*a*	1851, 1855, 1861	137	7	320	54
The Fossil Merostomata, by Mr. H. Woodward, in course of completion	1865, 1868, 1871, 1872	1866, 1869, 1872, 1872	180	30	249	35
The Post-Tertiary Entomostraca, by Mr. G. S. Brady, Rev. H. W. Crosskey, and Mr. D. Robertson, *complete*	1874	1874	237	16	515	134
The Tertiary Entomostraca, by Prof. Rupert Jones, *complete*	1855	1857	74	6	233	56
The Cretaceous Entomostraca, by Prof. Rupert Jones, *complete*	1849	1850	41	7	176	27
The Carboniferous Entomostraca, by Prof. Rupert Jones and Messrs. J. W. Kirkby and G. S. Brady, in course of completion	1874	1874	56	5	285	50
The Fossil Estheriæ, by Prof. Rupert Jones, *complete*	1860	1863	139	5	158	19*i*
The Trilobites of the Mountain-limestone, Devonian, Silurian, and other Formations, by Mr. J. W. Salter (incomplete through the Author's death)	1862, 1863, 1864, 1866	1864, 1865, 1866, 1867	216	31	703	114
The Malacostracous Crustacea (comprising those of the London Clay, Gault, and Greensands), by Prof. T. Bell, in course of completion	1856, 1860	1858, 1863	88	22	215	50
Fossil Brachiopoda, Vol. I. The Tertiary, Cretaceous Oolitic, and Liassic Brachiopoda, by Mr. T. Davidson, *complete*	1850, 1852, 1853, 1854	1851, 1852, 1853, 1855	409	42	1855	160
" " Vol. II. The Permian and Carboniferous Brachiopoda, *complete*	1856*d*, 1857, 1858, 1859, 1860	1858, 1859, 1861, 1861, 1863	331	59	1909	157
" " Vol. III. The Devonian and Silurian Brachiopoda, *complete*	1862, 1863, 1865, 1866, 1868, 1870	1864, 1865, 1866, 1867, 1869, 1871	528	70	2766	321
Supplement to the Fossil Brachiopoda, by Mr. Davidson, in course of completion	1873	1874	72	8	317	47
The Trigoniæ, by Dr. Lycett, in course of completion	1872, 1874, 1875	1872, 1874, 1875	148	27	270	83
		CARRIED FORWARD...	4595	640	14,539	2220

SUMMARY OF THE MONOGRAPHS ISSUED TO THE MEMBERS (*up to* DECEMBER, 1875)—*continued.*

I. SUBJECT OF MONOGRAPH.	II. Dates of the Years *for which* the volume containing the Monograph was issued.	III *m*. Dates of the Years *in which* the Monograph was published.	IV. No. of Pages of Letterpress in each Monograph.	V. No. of Plates in each Monograph.	VI. No. of Lithographed Figures and of Woodcuts.	VII. No. of Species described in the Text.
		BROUGHT FORWARD...	4595	640	14,539	2220
The Mollusca of the Crag, by Mr. S. V. Wood:—						
Vol. I. (Univalves), *complete*	1847, 1855*b*	1848, 1857	216	21	581	244
Vol. II. (Bivalves), *complete*	1850, 1853, 1855, 1858*c*	1851, 1853, 1857, 1861	344	31	691	253
Supplement to the Crag Mollusca, by Mr. S. V. Wood, *complete*	1871, 1873	1872, 1874	262	12	360	172
The Eocene Mollusca, Cephalopoda and Univalves, by Mr. F. E. Edwards, in course of completion	1848, 1852, 1854, 1855, 1858	1849, 1852, 1855, 1857, 1861	332	33	578	161
The Eocene Mollusca, Bivalves, by Mr. S. V. Wood, in course of completion	1859, 1862, 1870	1861, 1864, 1871	182	25	531	194
The Great Oolite Mollusca, by Prof. Morris and Dr. Lycett, *complete*	1850, 1853, 1854	1850, 1853, 1855	282	30	846	419
" " " Supplement by Dr. Lycett, *complete*	1861	1863	129	15	337	194
The Belemnites, by Prof. Phillips, in course of completion	1863, 1864, 1866, 1868, 1869	1865, 1866, 1867, 1869, 1870	128	36	622	69
The Upper Cretaceous Cephalopoda, by Mr. D. Sharpe, *complete*	1853, 1854, 1855	1853, 1855, 1857	67	27	319	79
The Fossils of the Permian Formation, by Prof. King, *complete*	1849, 1854*e*	1850, 1855	287	29	511	138
The Fishes of the Old Red Sandstone, by Messrs. J. Powrie and E. Ray Lankester, in course of completion	1867, 1869	1868, 1870	62	14	195	21
The Reptilia of the London Clay [and of the Bracklesham and other Tertiary Beds], by Profs. Owen and Bell, *complete* ‡	1848, 1849, 1856*f*	1849, 1850, 1859	150	58	304	39
The Reptilia of the Cretaceous Formations, by Prof. Owen, *complete* ‡	1851, 1857, 1858, 1862	1851, 1859, 1861, 1864	184	59	519	26
The Reptilia of the Wealden and Purbeck Formations, by Prof. Owen, *complete* ‡	1853, 1854, 1855, 1856, 1857, 1858, 1862	1853, 1855, 1857, 1858, 1859, 1861, 1864	155	62	251	17
The Reptilia of the Wealden Formations (Supplements) in course of completion	1871, 1873	1872, 1874	40	5	50	2
The Reptilia of the Kimmeridge Clay Formation, by Prof. Owen, in course of completion	1859, 1860, 1868	1861, 1863, 1869	16	6	23	3
The Reptilia of the Liassic Formations, by Prof. Owen, in course of completion	1859,‖ 1860,‖ 1863, 1869	1861, 1863, 1865, 1870	121	37	177	8
The Crag Cetacea, by Prof. Owen, in course of completion	1869	1870	40	5	43	7
The Pleistocene Mammalia, by Messrs. W. Boyd Dawkins and Mr. W. A. Sanford, in course of completion	1864, 1867, 1868, 1871	1866, 1868, 1869, 1872	266	32	250	7
The Fossil Mammalia of the Mesozoic Formations, by Prof. Owen, *complete*	1870	1871	115	4	247	30
The Fossil Reptilia of the Mesozoic Formations, by Prof. Owen, in course of completion	1873, 1875	1874, 1875	93	22	159	16
		TOTAL	8066	1203	22,133	4319

a Index. *b* Title-page to Univalves. *c* Note to Crag Mollusca. *d* Contains the Permian. *e* Two corrections of Plates. *f* Supplement.
g Many of the species are described, but not figured. *h* British species only reckoned. *i* British species only reckoned. *k* A Supplement is now in course of publication.
l Wants Index. *m* Useful for establishing the dates of new species.
‡ Title-pages and Index will be found in the 1864 Volume, or may be had separately. ‖ Marked on outside label 'Reptilia of Oolitic Formations.'

Stratigraphical Table *exhibiting the* British Fossils *already figured and described in the* Annual Volumes (1847—1875) *of the* Palæontographical Society.

		PROTOZOA.		RADIATA.		ARTICULATA.					
	PLANTS.	Sponges.	Foraminifera.	Corals.	Echinodermata.	Cirripedes.	Cypridæ, Cytherinæ, &c.	Estheriæ.	Merostomata.	Trilobites.	Malacostracous Crustacea.
Pleistocene	...	...	...	...	......	......	1874				
Crag	...	...	1865	1849	1852	1851 1854					
Eocene	...	...	...	1849 1865	1852	1851 1854	1855	...	......	......	1856
Cretaceous.........	...	...	...	1849 1868 1869	1862 1867 1869 1870 1872 1873 1875	1851 1854	1849	...	......	......	1860
Wealden	...	...	...	...	......	......	...	1860			
Oolitic	...	...	...	1851 1872	1855, 1856, 1857, 1858, 1861	1851	...	1860			
Liassic	...	...	...	1851 1866 1867	1855, 1856, 1858, 1861, 1864						
Triassic	...	...	...	...	......	......	...	1860			
Permian	1849	1849	1849	1849 1852	1849	......	1849	1860			
Carboniferous...	1867 1870 1871 1875	...	...	1852	......	......	1874	1860	1872		
Devonian	...	...	...	1853	......	......	...	1860	1865 1868 1872	1862	
Silurian............	...	...	...	1854	......	......	...	...	1868 1871 1872	1862, 1863 1864, 1866	
Cambrian	...	...	...	...	......	......	...	...	......	1864	

Note.—The numbers in the above List refer to the Volumes issued for those Dates.

STRATIGRAPHICAL TABLE *exhibiting the* BRITISH FOSSILS *already figured and described in the* ANNUAL VOLUMES (1847—1875) *of the* PALÆONTOGRAPHICAL SOCIETY (*continued*).

	MOLLUSCA.				VERTEBRATA.		
	Polyzoa.	Brachiopoda.	Monomyaria, Dimyaria, and Gasteropoda.	Cephalopoda.	Fishes.	Reptiles.	Mammalia.
Pleistocene	...	1873	......	...	...	......	1864, 1867, 1868, 1871
Crag	1857	1852, 1873	1847, 1850, 1853, 1855, 1871, 1873	...	...	......	1869
Eocene	...	1852, 1873	1852, 1854, 1855, 1858, 1859, 1862, 1870	1848	...	1848, 1849, 1856	
Cretaceous.........	...	1852, 1854, 1873	1872, 1875	1853, 1854, 1855	...	1851, 1857, 1858, 1862	
Wealden	...	......	......	...	...	1853, 1854, 1855, 1856, 1857, 1862, 1871, 1873, 1875	
Oolitic	...	1850, 1852	1850, 1853, 1854, 1872, 1874, 1875	1850, 1861, 1868, 1869	...	(Purbeck) 1853, 1858 (Kim. Clay), 1859, 1860, 1868, 1873, 1875, (Great Oolite) 1875	1870
Liassic	...	1850, 1852	1874	1863, 1864, 1866, 1868	...	1859, 1860, 1863, 1869, 1873	
Triassic............	...	......	......	......	......	......	1870
Permian	1849	1849, 1856	1849	1849	1849	1849	
Carboniferous ...	...	1856, 1857, 1858, 1859, 1860					
Devonian	...	1862, 1863	......	...	1867, 1869		
Silurian............	...	1865, 1866, 1868, 1870					
Cambrian							

NOTE.—The numbers in the above List refer to the Volumes issued for those Dates.

THE

PALÆONTOGRAPHICAL SOCIETY.

INSTITUTED MDCCCXLVII.

VOLUME FOR 1875.

LONDON:

MDCCCLXXV.

OBSERVATIONS

ON THE

STRUCTURE OF FOSSIL PLANTS

FOUND IN THE

CARBONIFEROUS STRATA.

BY

E. W. BINNEY, F.R.S., F.G.S.

PART IV.

SIGILLARIA AND STIGMARIA.

Pages 97—147; Plates XIX—XXIV.

LONDON:
PRINTED FOR THE PALÆONTOGRAPHICAL SOCIETY.
1875.

PRINTED BY
J. E ADLARD, BARTHOLOMEW CLOSE

CONTENTS.

PART IV.

SIGILLARIA AND STIGMARIA.

I. Introductory Remarks.

In this Part of my Monograph it is intended to give a summary of the present state of our knowledge on the structure of *Sigillaria* and the allied plants, rather than descriptions of many new specimens. Further information, however, on *Sigillaria vascularis* will be given; and a *Stigmaria*, not only showing structure in the medulla, but in every respect agreeing with *Sigillaria vascularis*, will be figured and described. Some additional information on *Stigmaria* will also be furnished; and the structure of its rootlets, as well as the remarkable sutures dividing the base of the stem of *Sigillaria*, will be treated more at length than they have been in my previous papers.

Since the publication of my views, that large and small specimens of *Sigillaria vascularis*, as well as *Diploxylon cycadoideum*, had piths formed of barred tubes, and not parenchyma, several authors have doubted the correctness of the description given of my specimens, and asserted that such plants, as well as *Stigmaria*, had piths of parenchyma similar to those of the *Lepidodendron Harcourtii* described in this Monograph. More evidence will be adduced in support of my views, and it is hoped that it will be conclusively shown that at least one *Stigmaria*, and that the only specimen of the kind ever described with a pith in a perfect state of preservation, had a pith composed of barred tubes and cells. What was the structure of other *Stigmariæ*, so far as regards their piths, yet remains to be proved; and we must wait patiently for the discovery of specimens in such a state of preservation as to afford us the desired information. This may come any day, now such diligent search is being made for the discovery of Coal-measure Plants showing structure.

In the present as well as in the former Parts of this Monograph it has been my endeavour to describe the most perfect specimens that could be procured, showing the appearance of the exterior of the plant as well as its internal structure; as I have always found great difficulties in examining imperfect fragments of plants, however well their structure may have been preserved.

A great amount of labour, no doubt, has still to be devoted to the study of the structure of many of our common Coal-measure Plants before we can speak on all points with positive certainty.

II. General Observations on Sigillaria, Anabathra, Diploxylon, and Stigmaria.

Ever since the time when the Fossil Plants of the Coal-measures first attracted attention, *Sigillaria* has occupied a chief place in the minds of botanists; for it is to be met with in the strata near most seams of coal, in a more or less perfect state of preservation. The trunks of this genus are of two kinds, namely, those distinctly ribbed and furrowed, with leaf-scars on the ribs at greater or less distances, and those with the leaf-scars contiguous, and covering the whole surface of the trunk; both having them in a spiral arrangement around the axis. Nearly one hundred species have been described by different authors, who have made numerous species out of the same trunk; various parts of it being in a bad or good state of preservation. No doubt, when we are better acquainted with the true nature of the plant, the number of species will be greatly reduced.

For a long time *Sigillaria* and *Stigmaria* were regarded as distinct genera of plants, and even now, on the Continent, some distinguished palæontologists are disposed to remain of that opinion. In the specimens first described by me, in the 'Philosophical Magazine' for 1844,[1] which were found in Mr. Littler's quarry, near St. Helen's, *Stigmaria* was clearly traced to the trunks of the large, irregularly ribbed and furrowed *Sigillariæ*, showing little, if any, traces of leaf-scars; but it was there distinctly stated that around these trunks smaller trunks were found standing, which showed all the characters of *Sigillaria reniformis*, with *Stigmaria* rootlets in the adjoining strata, pointing in the direction of the root, but not absolutely proved to be connected with it. On viewing the specimens as they originally stood in the quarry before their removal, little doubt could be entertained as to all the trees there found having had *Stigmariæ* for their roots. In some specimens, however, afterwards described by me in the 'Philosophical Magazine' for 1847, ser. 3, vol. xxxi, p. 259, the connection of *Stigmaria*, as a root, with *Sigillaria reniformis*, *S. alternans*, and *S. organum*, was clearly proved.[2]

The regularly ribbed and furrowed *Sigillaria*, with distinct leaf-scars, generally found flattened and compressed in the sandstones and shales, are seldom of so large a size as

[1] 'Phil. Mag., ser. 3, vol. xxiv, p. 168; and 1845, vol. xxvii, p. 241, &c.

[2] See also 'Quart. Journ. of Geol. Soc.,' vol. ii, p. 391.

those irregularly ribbed and furrowed stems described by me under the name *Sigillaria vascularis*, sometimes attaining seven feet in diameter. In the fossil forests of trees standing erect in the Coal-measures, which have come under my observation, nearly all belong to the last-named genus. In the Pemberton Hill Cutting, on the railway between Wigan and Liverpool, six out of thirty stems, from one to two feet in diameter, exhibited the scars of *Sigillaria reniformis*, *S. alternans*, and *S. organum;* the remaining twenty-four belonging to *S. vascularis*. On the numerous fossil trees found in cutting the Clay-Cross tunnel, on the Midland Railway, near Chesterfield; in the specimens found in the deep pit at Pendleton, some of which were more than fifty feet in height; in that from the Victoria pit, Dukinfield, now in the Manchester Museum; in those on the Manchester and Bolton Railway, at Dixon Fold, described by Messrs. Hawkshaw and Bowman; and in the large stems from the Trap-Ash, of Laggan Bay, discovered by Mr. Wünsch; there was no evidence of distinct leaf-scars, but only irregular ribs and furrows. All the specimens except the last named were seen and examined by me *in situ*. The only example of a very large *Sigillaria* showing distinct leaf-scars, which has come under my observation, is specimen "No. 49" of *Sigillaria reniformis*, now in the Museum of the School of Mines in Jermyn Street. Unfortunately, all the above-mentioned specimens, except those from Laggan Bay, afford no traces of internal structure. These last, however, some of which are about two feet in diameter, afford evidence of the structure of the thick inner bark, termed by me the outer radiating cylinder, and the woody or inner radiating cylinder of barred tubes, containing vascular bundles and medullary rays, enclosing a medulla, composed of barred tubes, in all respects exactly similar in structure to the large *Sigillaria vascularis*, with irregular ribs and furrows, described by me in the 'Philosophical Transactions;'[1] and the smaller specimens, exhibiting on their outsides scars of *Lepidodendron*, described in the 'Quarterly Journal of the Geological Society.'[2] These large and small specimens gradually pass one into the other, as numerous specimens in my cabinet, in addition to those figured, amply testify. Many persons have become accustomed to class my small specimens, the first ever described showing a medulla of vascular tubes, as *Lepidodendra*, from their external characters, without regarding their inner radiating cylinder and its singular medulla, so totally different in arrangement to the vascular cylinder and medulla of orthosenchymatous tissue of *Lepidodendron Harcourtii* before described in this Monograph.

When M. Brongniart described the structure of *Sigillaria elegans* he had before him, and described in the same Memoir as perfect specimens of *Lepidodendron* and *Stigmaria*, with the exception of the medulla and outer radiating cylinder, as have been met with up to this time; and he alludes to the probability of *Stigmaria* being the root of *Sigillaria;* but he notices the remarkable difference in structure between *Sigillaria* and *Lepidodendron*.

[1] For 1865, p. 579 *et seq.*

[2] Vol. xviii, 1862, p. 111.

The large *Sigillaria*, described in the 'Philosophical Transactions,' does not show many cicatrices of leaves on its outside, and is not of great size as a specimen of that genus, but it is the largest found by me in a calcareous nodule in a seam of coal. It is probable that it may have been portion of a main root, rather than a stem; for those portions of *Sigillaria*, whatever the characters of the stem, show nothing but irregular ribs and furrows on their surface. There are generally twenty-four of these main roots to one stem. In structure, however, it agreed with Brongniart's *Sigillaria elegans* more than any other then known plant; and it was classed with *Sigillaria* chiefly on that ground.

Owing to the small size of the nodules in coal, in which the fossil wood is found, we can never expect to find any very large specimens; for ten inches is the diameter of a very large nodule. Portions of *Sigillaria reniformis*, *S. alternans*, *S. catenulata*, *S. tesselata*, and *S. organum* have come under my observation, clearly showing the structure of the outer radiating cylinder or inner bark (first noticed in Brongniart's specimen), sometimes reaching to as much as five or six inches in thickness, and enveloped in a stout outer bark, converted into bright coal; but they are all destitute of the internal radiating cylinder and the medulla. The absence of the latter is what might have been anticipated, as it is so generally absent in *Stigmaria;* but why the former should not be met with is not so evident, except that in large trees, at the present day, decomposition commences in the centre, and extends towards the circumference; and so it may have been in ancient times. The tannin in the bark may have had greater power to resist decomposition than the inner parts of the tree.

In my figured specimens of small *Sigillaria vascularis*, the medulla is in a perfect condition; but in the large specimens of that plant, and in *Diploxylon*, described by me in the 'Philosophical Transactions' for 1865, the central portion of the medulla is somewhat disarranged. Since the publication, however, of that Memoir fresh transverse sections of the large specimen of *S. vascularis* have been made, which prove beyond question that the whole of the medulla is composed of barred tubes.

In my description of the inner radiating cylinders of the large specimens, mention is made of medullary rays of various breadths, some much narrower than the diameter of the tubes they traverse, and others considerably broader, corresponding with what Professor Williamson has since designated "primary and secondary rays." These are termed medullary rays or bundles[1] in the Memoir, and they chiefly relate to the primary rays, but there are also numerous medullary rays of one and two cells in breadth. They were met with in both *Diploxylon* and *Sigillaria vascularis;* and, although the divisions in the radiating cylinder of the former might appear to indicate that vascular bundles,

[1] In my paper I used the term "medullary rays or bundles," owing to the large rays being composed of vascular tubes and not of cellular tissue, as is generally the case in recent plants; but the smaller ones were of cellular tissue, like ordinary medullary rays. Objection may be made to the term, but in using it no hypothesis is advanced.

similar to what Corda had described in his specimen, had occupied them, none were seen. The rays, whether the large oval or the small ones, consisting of a series of single or double cells in a vertical line, were not distinctly shown in the longitudinal section, however large, but only in the tangential sections, which is rather singular. The larger or primary rays in the inner radiating cylinder were in no case absolutely traced to those traversing the outer cylinder, but in the small *S. vascularis*, figured in the woodcut No. 5 (p. 594), they were distinctly seen proceeding from the *outside* of the inner to the exterior of the outer radiating cylinder. Still, they were not absolutely proved to be connected with the inner primary rays. These latter, as previously stated, were only seen in tangential section, so it is difficult to speak with certainty whether they were composed of barred tubes or not.

Since the publication of my Memoir all my specimens of *Diploxylon* and *Sigillaria* have been again carefully examined in their longitudinal sections, and traces of vascular bundles like those so frequently found in common *Stigmaria,* and which form so marked a character in Corda's *Diploxylon cycadoïdeum*, have been found; but certainly not so distinctly, or communicating with the medulla, as shown in the transverse and longitudinal sections of his specimens.

In the outer radiating cylinder, or inner bark, the foliar bundles, enveloped in masses of very large and lax parenchyma, of a double-cone form, noticed by Professor King, are seen traversing the prosenchymatous tubes and pushing them aside; but these are shown chiefly in the tangential section, although a few traces of them are met with in the longitudinal section. One of the best examples hitherto met with is that figured in plate 34, fig. 2, of my Memoir in the 'Phil. Trans.' for 1865. These characters are much the same, whether observed in the large specimens, with irregular ribs and furrows, or those with rhomboidal scars on their outsides, like fig. 5, in plate 35, of that Memoir; thus showing, by their structure, that both specimens most probably belong to one plant. In the midst of this lax tissue the bundle of vascular tubes, in tangential section, presents a kidney shape, similar to what MM. Renault and Grand' Eury have noticed in *Sigillaria spinulosa*. In none of my sections, however, has there been seen any indication of the anastomozing observed by those authors in transverse and longitudinal sections of their specimen.

As the stems grow larger the lax cellular tissue enveloping the foliar bundles becomes less, so that in an outer radiating cylinder, five to six inches in breadth, little of it is seen; and what does appear is far more compact in structure than the very large cells of lax parenchyma seen nearer the centre. The wedge-shaped masses of parenchyma containing the foliar bundles of vascular tissue divide the wedge-shaped masses of prosenchymatous tissue; and these wedges have their thin and thick ends opposite to each other, the one increasing inwards and the other outwards. It is most probable, owing to the very large size of the cells of this lax parenchyma, that the space between the inner and outer radiating cylinders in *S. vascularis* is so often wanting in structure.

My neighbour Professor Williamson has described some portions of *Diploxylon, Sigillaria*, and *Stigmaria*,[1] which, he thinks, confirms his opinion that all these plants had piths composed of parenchyma, and not piths of vascular tubes of various sizes, and sometimes more or less mixed with orthosenchymatous tissue, as I had described as occurring in the two first-named genera; in fact, that their piths and the pith of *Lapidodendron Harcourtii* were much the same in structure.

My specimens described in the 'Quarterly Journal of the Geological Society' and in the 'Phil. Transactions' were probably in a more perfect state than any figured and described previously, so far as *Diploxylon* and *Sigillaria* were concerned. As for *Stigmaria* no one had described the pith except Goeppert[2] and myself; and both of the specimens described by us were looked upon as more than doubtful by recent writers. Professor Williamson says, "I have elsewhere called attention to the way in which the rootlets of *Stigmaria* have penetrated everything within their reach that was penetrable; and I have no doubt that in both Professor Goeppert's and Mr. Binney's specimens these supposed medullary vessels were really Stigmarian rootlets that had found their way into the interior of the cavity left by the decay of the medulla, and been mistaken for a part of the plant into which they had intruded themselves." Now, in my Staffordshire specimen, which exhibited all the external characters of *Stigmaria ficoides*, mention is made only of the large vascular bundles found in the axis, without calling them medullary or any other vessels. As figured in the plate and described in the letterpress no one could scarcely take them for the rootlets of *Stigmaria*. The woody cylinder was one of those having the inner parts of their circle close together, and not open, as in Professor Goeppert's specimen. It is possible that the large tubes in my specimen are not in their normal condition; and they may have been somewhat altered in the process of mineralisation; but it is very improbable that they were ever introduced into the axis after the pith had been removed. The specimen figured and described by Goeppert is very different from mine, being more open in the spaces between the wedges of the woody cylinder; and its central part is enclosed in a *Stigmaria*, showing the exterior in a most beautiful state of preservation. It appears to me that the vascular bundles in the pith, though it might be urged that they have been squeezed from their true position between the wedges of the inner radiating cylinder into the parts where they are now found, are certainly not intruded rootlets. In comparing Geoppert's and my specimens with Professor Williamson's any one will see that they are in a much more perfect state of preservation than the Oldham fragments.

Many beautiful specimens of *Stigmaria*, showing structure, have been met with in the trap-ash of Scotland by Mr. Greive and Mr. John Young of the Hunterian Museum, Glasgow, to both of whom I am much indebted for their kindness in presenting me with

[1] 'Phil. Transactions,' 1872; Part II of the Professor' Memoir "On the Organisation of the Fossil Plants of the Coal-measures," p. 215.

[2] 'Genres des Plantes fossiles,' pl. 13.

specimens. But all these have lost their piths, and fail to give us any information as to what they were composed of.

Some years since I found a specimen in the "Bullion" seam of coal at Clough Head, near Burnley, having every part of the medulla beautifully preserved; and, although showing little trace of the exterior of a *Stigmaria,* it affords undoubted evidence, in its transverse section, of several bell-shaped cavities, from which the rootlets proceeded. In every portion this plant resembles in structure the specimens of *Sigillaria vascularis,* formerly described by me in the 'Quarterly Journal of the Geological Society' and the 'Philosophical Transactions;' and, if perfect identity of structure is to be taken as proving the connection of root and stem, this must be held to be the root of that plant. It also shows the occurrence of barred tubes or utricles of very large size, almost as large as those found in my Staffordshire specimen, on which so much doubt had been thrown.

Another specimen of *Stigmaria* was found by me in the same locality as the last, having the open spaces between the wedge-shaped masses of wood freely communicating with the medulla, and not bounded by the dark line so marked in my Staffordshire specimen, and the one showing structure from Clough Head. Both specimens exhibit vascular bundles and medullary rays, traversing the woody cylinder alike; but the last-mentioned specimen has lost nearly all its medulla. It is now described for the purpose of showing its difference in structure from the first-mentioned specimen. In my paper on *Sigillaria* and *Diploxylon* in the 'Philosophical Transactions,' 1865, it is stated (p. 585) that "the lunette-shaped extremities of the inner radiating cylinder of *Diploxylon cycadoideum,* as well as those in my specimen, remind us of a similar arrangement shown to occur in *Stigmaria* by Dr. Hooker, Plate 2, fig. 14, 'Memoirs of the Geological Survey of Great Britain,' vol. ii, Part I; and they appear to differ from those found in *Sigillaria vascularis* in not being divided from the central axis by a distinct line of demarcation, just as the same author's *Stigmaria,* fig. 5, differs from fig. 14. The interior of the inner radiating cylinder of the former plant is more free and open, and not so sharp and compact as that of the latter plant. Indeed, from structure alone it would appear probable that the first-named *Stigmaria* was the root of *Diploxylon,* whilst the last one was the root of *Sigillaria vascularis.*"

In the memoirs published on the structure of fossil plants it has always been stated by me that *Lepidodendron* was closely allied to *Sigillaria;* but, as previously mentioned in this Monograph, *L. Harcourtii* contains a medulla of orthosenchymous tissue, and no inner radiating cylinder; and, on the other hand, *Sigillaria vascularis* has a medulla composed of large and small vascular tubes, and an inner radiating woody cylinder. My opinion has been formed from an examination of my own specimens; and other authors may have reasons, unknown to me, for classing *Sigillaria vascularis* as a *Lepidodendron.*

M. Bronguiart, who has given to the world nearly all the knowledge we possess of the structure of *Sigillaria elegans,* never supposed that his plant was a *Lepidodendron,*

however much he observed its resemblance in structure to *Stigmaria*, so as to induce him to believe that the latter plant was the root of the former. As previously stated, *Halonia regularis* is most probably the root of *Lepidodendron Harcourtii*, if identity of structure can prove it. The vascular bundles and medullary rays can often be distinctly seen in the transverse section of *Diploxylon cycadoideum*, and in the *Stigmaria*, with wide spaces between the woody wedges; but, so far as my knowledge extends, they have not yet been found in *Sigillaria vascularis* and the close-wedged *Stigmaria*, communicating with the outside of the woody cylinder next to the medullary sheath or the medulla itself. The last-named kind of *Stigmaria* has only been described by Dr. Hooker and myself; even so exhaustive an author as Professor Schimper does not figure nor allude to one. In my experience the one kind is nearly as common as the other.

Up to the present time little information has been published on the organs of fructification of *Sigillaria* with the exception of the cone described by me in the 'Philosophical Transactions,' 1865, p. 595. That specimen was very imperfectly figured in the woodcut (fig. 6); but from the form and arrangement of the bracts, and their resemblance to the form and arrangement of the leaf-scars of *Sigillaria organum*, I am strongly inclined to believe that it belongs to some species of *Sigillaria*.

The specimen described by Goldenberg does not appear to me to have belonged to a large-ribbed-and-furrowed *Sigillaria*. It is to be hoped, however, that some cones will soon be met with showing the structure of the central column to be the same as that of *S. elegans* or *S. vascularis*, as was proved to be the case with *Lepidostrobus* and *Lepidodendron* previously shown in this Monograph.

The specimen "No. 19 Cone," described at p. 49 of this Monograph, so far as structure goes, is the nearest to that of the stem of *Sigillaria vascularis* of any that have come under my observation; but that does not go so far as to prove perfect identity of structure. It affords little evidence of the characters of the spores; indicating microspores only.

III. Bibliography.

In giving a summary of what has been published on *Sigillaria* it is only possible to quote the opinions of those authors who have written on the structure of the plant, without noticing the numerous writers who have described its external characters. The only exception to this rule is the insertion, at length, of the Rev. Mr. Steinhaur's Memoir on *Stigmaria*. This is so full and true a description of the root, its author being, too, the first to surmise that *Stigmaria* might be a root, that it appears desirable to give the paper at length. The views of the authors are generally given in their own words.

1. Steinhaur[1] (Roots).—" Sp. 1. *Phytolithus verrucosus*, plate iv, figs. 1—6. Martin, 'Petrificata Derbiensia,' plates 11, 12, and 13; Parkinson, 'Organic Remains,' vol. i, pl. 111, fig. 1.

" The fossil which has received this name from the ingenious author of the 'Petrificata Derbiensia' is by far the most common, and perhaps the most remarkable, of this class. Woodward seems already to have collected numerous specimens, notwithstanding their bulk and comparative unsightliness ('Catalogue of English Fossils,' vol. i, part 2, p. 104; vol. ii, p. 59, &c.); and Mr. Parkinson has exercised considerable, though fruitless, ingenuity in elucidating them. It might appear presumptuous, after the labours of men of such distinguished abilities, to obtrude to public notice any further remarks, had not these authors left abundant room for observation, which place of abode and inclination have enabled the writer to pursue during a series of several years. Within this period we have collected several hundred specimens, worked many from the bed of clay in which they were embedded, and examined in quarries, on coalpit hills, among heaps of stone by the roadside, and in various other situations, several thousand. The geological situation of this fossil is well known to be the coal strata, in almost all which, as far as the writer is enabled to judge, it is found. Its geographical habitats in these strata may be partly collected from the works already quoted. The specimens more immediately examined were found in the neighbourhood of Fulneck, near Leeds, or in the space included by the towns of Leeds, Otley, Bradford, Halifax, Huddersfield, and Wakefield; but I have also found it on the top of Ingleborough; in the Coal strata of Northumberland; abundantly in Derbyshire; at Dudley in Shropshire; and in the neighbourhood of Bristol. With respect to mineralogical constituent matter, it seems always to coincide with that of the stratum in which it is imbedded, with a slight modification of density. It is most abundant in the fine-grained siliceous stone provincially called 'Calliard' and 'Ganister,' and in some of the coal 'Binds' or 'Crowstones,' which have probably received this appellation from spots of bitumen or coal attached to these petrifactions. It is rather less frequent in the beds of scaly clay or clay mixed with siliceous sand and mica; very common, but completely compressed, in the coal shales or bituminous slate-clay; of occasional occurrence in the argillaceous iron-stone; not rare in the common grit, and upper thick beds of argillaceo-micaceous sandstone, or rag, and sometimes, though rarely, discoverable in the coal itself. Mr. White Watson, of Bakewell, had also in his collection, which we examined, a specimen in the Derby Toadstone or Trap; and we have also noticed it in the limestone behind the Bristol Hot Wells, at its junction with the sandstone. So immense, however, is the number of relics that, when the eye has been accustomed to catch their appearance, it is scarcely possible to walk a furlong in the districts where they are at home without meeting them in one shape or another. The most perfect form in which this fossil occurs is that of a cylinder more or

[1] 'Transactions of the American Phil. Soc.,' vol. i, p. 265, 1868.

less compressed, and generally flatter on one side than the other (plate iv, figs. 1 and 2). Not unfrequently the flattened side turns in so as to form a groove. The surface is marked in quincuncial order with pustules, or rather areolæ, with a rising in the middle, in the centre of which rising a minute speck is often observable. From different modes and degrees of compression, and probably from different states of the original vegetable, these areolæ assume very different appearances; sometimes running into indistinct rimæ like the bark of an aged willow; sometimes, as in the shale impressions, exhibiting little more than a neat sketch of the concentric circles (figs. 4, 5, 6). Mr. Martin suspected that these pustules were the marks of the attachment of the penduncules of leaves, and pl. xii represents a specimen in which he thought that he had discovered the reliquiæ of the leaves themselves. We have examined the specimen when the drawing, which is extremely correct, was made, but are convinced that Mr. Martin was misled by an accidental compression in describing these leaves as being flat. Numerous specimens in 'Ganister,' in which the lateral compression of the trunk is generally trifling, place the assertion beyond a doubt that the fibrous processes, acini, spines, or whatever else they may be called, are cylindrical; and small fragments of these cylinders show distinctly a central line (pith) coinciding with the point in the centre of the pustule. Convinced of the existence of these fibres, we were soon able to detect their remains, forming considerable masses of stone, particularly of Coal-bind, on Wibsey Slack and at Lower Wike, where their contorted figure imitates the figure of Serpulæ; but it excited much surprise, on examining the projecting ends of some trunks which lay horizontally in a bed of clay, extending along the southern bank of the rivulet which separates the townships of Pudsey and Tong, and which is exposed by slips in several places, to find traces of these fibres proceeding from the central cylinder, in rays through the stratum, in every direction, to the distance of above twenty feet. Repeated observations, and the concurrent conviction of unprejudiced persons made attentive to the phenomenon, compelled the belief that they originally belonged to the trunks in question, and consequently that the vegetable grew in its present horizontal position at a time that the stratum was in a state capable of supporting its vegetation, and shot out its fibres in every direction through the then yielding mud. For if it grew erect, even admitting the fibres to be as rigid as the firmest spines with which we are acquainted, it would be difficult to devise means gentle enough to bring it into a recumbent posture without deranging their position. This supposition gains strength from the circumstance that they are found lying in all directions across one another and not to any particular point of the compass.

"The flattened and sometimes grooved form of one side of the cylinder has already been noticed. Woodward already observed that along this side there generally, or at least frequently, ran an included cylinder, which at one extremity of the specimen would approach the outside, so as almost to leave the trunk, while on the other end it seemed nearly central. A reference to his 'Catalogue,' vol. i, part 2, p. 104, to Mr. Parkinson's 'Organic Remains,' vol. i, p. 427, and to Martin's 'Petrificata Derbiensia,' fig. 1 *c*, will

show how much this included cylinder has embarrassed those who have considered it with a view to the vegetable organ to which it owes its origin. In the specimens of Calliard, which have suffered little compression, but which are seldom above a few inches in length, this body is generally nearly central; perhaps in no instance perfectly lateral. In the specimens in clay, from one of which we were able to detach upwards of 6 feet, the flattened or grooved side is invariably downward; and consequently the included cylinder is in the position which it would assume if it had subsided at one end, while the other was supported, or which would be the result of its sinking through a medium of nearly the same specific gravity with itself, provided it was at one end rather denser than at the other. It must be observed that this included body appears to have suffered various degrees of compression, being sometimes cylindrical, which was evidently its original form, and sometimes almost entirely flattened. In the coal shale we were never able to detect a trace of its existence.

"Besides these indications of organisation, we have met with several specimens which, on being longitudinally split, discovered marks of perforations or fibres, more or less parallel with the axis of the cylinder, and in some degree resembling the perforations of Terebellæ in the fossil wood of Highgate and some other places. Whether these configurations be owing to the organisation of the original vegetable, or to some process which it underwent during its decay, seems impossible to determine; the specimens examined afforded no opportunity of discovering a connection between these tubes and either the internal cylinders or the external surface.

"Among the vast number of specimens examined, only one was detected which appeared to terminate, closing from a thickness of 3 inches to an obtuse point. We have given a figure of it, pl. 4, fig. 3. Two instances also came to our knowledge of branched specimens, in which the trunk divided into nearly two equal branches. So rare an occurence of this circumstance would, however, rather induce the supposition that the original was properly simple, and that these were only exceptions or monstrosities. The size of different species varies greatly; but we have seen none under 2 inches in diameter; the general size is 3 or 4, and some occur, but with very indistinct traces of the pustules, even 12 inches across.

"From the above, it appears rational to suppose that the original was a cylindrical trunk or root, growing in a direction nearly horizontal in the soft mud at the bottom of fresh-water lakes or seas, without branches, but sending out fibres from all sides; that it was furnished in the centre with a pith, of a structure different from the surrounding wood or cellular substance, more dense and distinct at the older end of the plant and more similar to the external substance towards the termination, which continued to shoot; and perhaps that, besides this central pith, were longitudinal fibres proceeding through the plant, like those of the roots of the *Pteris aquilina*. With respect to any stem arising from it, if a root or foliage belonging to it, if a creeping trunk, we have hardly ground for a supposition."

2. WITHAM[1] (Stem) describes his *Anabathra pulcherrima*, found in the Mountain-limestone series at Allenbank, in Berwickshire, as follows :—" A medullary axis ; woody tissue consisting of elongated cellules; medullary rays scattered at great distances. Stems roundish or compressed, tapering; pith of irregular polygonal cellules; woody tissues, in the transverse section, presenting the appearance of regular, parallel, radiating series of four-sided or subhexagonal cellules, with radiating tubular ducts interspersed at intervals. In the longitudinal sections the cellules have all their walls very regularly marked with parallel straight lines or ridges. The medullary rays, in their transverse section, are of an elliptical form, and composed of irregular reticulations."

3. LINDLEY and HUTTON[2] (Roots).—Describing Mr. Prestwich's specimen of *Stigmaria*, they state—" The transverse section exhibited a meshing, something like that of Coniferæ, but with no concentric circles, and with the medullary rays consisting rather of open spaces between the other tissue, than of common muriform tissue found in such places. The longitudinal section (fig. 2) presented an assemblage of spiral vessels, of a very tortuous and unequal figure, without any woody or cellular matter intermixed.

" These formed a cylinder, which was surrounded externally by a mass of inorganic mineral matter, upon which surface the peculiar markings of *Stigmaria* were preserved, and which enclosed a hollow cavity, altogether destitute of mineral deposit.

" It would therefore appear that *Stigmaria* was a plant with a very thick cellular coating or bark, surrounding a hollow cylinder, composed exclusively of spiral vessels and containing a rather thick pith ; and that the plates of cellular tissue, which preserved the communication between the bark and the pith, were of so delicate an organisation that they disappear under the mineralising process which fixed the organic characters of the wood."

4. BRONGNIART[3] (*Sigillaria*, &c.).—" En faisant abstraction des colorations diverses de la silice qui occupe les parties dans lesquelles le tissu est complétement détruit, on voit que cette tige est formée de deux cylindres de tissus plus résistants, et dont la texture est parfaitement conservée, cylindres qui ne sont pas concentriques l'un à l'autre ; l'un, tout-à-fait extérieur et superficiel, constitue une sorte d'écorce, et présente extérieurement les bases saillantes, ou mamelons rhomboïdaux, qui correspondent aux points d'insertion de chaque feuille ; le tissu qui le compose, et qui parait parfaitement continu, est cellulo-fibreux, très-fin et très-dense ; l'autre cylindre, intérieur, rapproché d'un côté du cylindre extérieur, en est séparé par un espace assez large sur un côté, étroit de l'autre, qui parait avoir été occupé par un tissu cellulaire délicat (pl. i, figs. 3, 4, *e e'*), dont il ne reste de trace que dans quelques points, et surtout près de la zone corticale ou extérieure; ce tissu cellulaire est représenté pl. ii, figs. 1, 2, 3, *e'* ; *e'*, l'intérieur de ce même cylindre (pl. i, figs. 3, 4, *a a ;* pl. ii, 1 *a*) ne présente que de la silice amorphe, transparente ou

[1] 'On the Internal Structure of Fossil Vegetables,' p. 74, Edinburgh, 1833.

[2] 'Fossil Flora,' &c., by Lindley and Hutton, vol. iii, p. 47, 1838.

[3] 'Archives du Muséum d'Histoire Naturelle,' &c., tome i, p. 410, 1839.

opaque, incolore ou diversement colorée, mais qui a pris probablement la place d'un tissu cellulaire, analogue à celui dont il reste quelques traces entre l'écorce et le cylindre intérieur.

" Quant à ce cylindre creux, à cette sorte de tube excentrique, la disposition et la nature des parties qui le constituent méritent de fixer en premier notre attention, car il représente le système vasculaire ou ligneux de la plante.

" Il forme un cylindre parfaitement régulier, de 13 à 14 millimètres de diamètre intérieur, et d'un millimètre d'épaisseur, composé d'un nombre déterminé de faisceaux, tous parfaitement égaux et semblables, placés les uns à côté des autres, sans aucun intervalle appréciable dans la plupart des cas, mais distincts par la forme arrondie de chacun d'eux du côté intérieur, ce qui donne au bord interne, sur la coupe transversale, une forme festonnée.

" Il suffit d'un faible grossissement pour reconnaître que chacun de ces faisceaux est formé de deux zones distinctes, l'une interne, constituant ces sortes de festons, l'autre externe, beaucoup plus étendue. Ces deux zones, quoique immédiatément contiguës, se distinguent facilement par une modification dans leur aspect et dans leur coloration vers leur point de contact ; mais un plus fort grossissement rend bientôt compte des différences de leur organisation.

" Sur la coupe transversale (pl. i, fig. 4 *b*, et pl. iii, fig. 1 *b b'*), on voit que les parties internes des faisceaux, ayant la forme d'un segment de cercle dont la convexité est tournée intérieurement, sont formées entièrement par un tissu dont les parois ont la même épaisseur et le même aspect ; ce sont, comme on le verra plus tard, des vaisseaux[1] à parois rayées transversalement ou obliquement, ou même réticulées, dont les orifices, anguleux et irréguliers, sont disposés sans ordre, mais dont les plus grands (*b*) sont du côté du centre du cylindre, les plus petits (*b'*), au contraire, vers l'extérieur et appliqués contre la zone externe de ce cylindre vasculaire.

" Cette zone extérieure (pl. i, fig. 3, 4, *c* ; pl. iii, fig. 1, *c c'*) est formée par un tissu disposé avec une grande régularité, en séries rayonnantes, tantôt tout-à-fait contiguës, tantôt séparées par d'étroits intervalles, occupés par des rayons médullaires, dont le tissu est maintenant détruit. Les orifices des vaisseaux (car ce sont encore des tubes rayés qui constituent toute cette zone) dont chacune de ces séries est composée vont en diminuant vers l'intérieur, les plus petits (*c*) étant presque en contact avec les plus petits vaisseaux des faisceaux internes, et ces vaisseaux d'un petit calibre formant, par leur rapprochement, mais sans se confondre, la ligne de démarcation entre les faisceaux internes, composés de vaisseaux disposés sans ordre, et les faisceaux externes, dont les vaisseaux sont disposés en séries rayonnantes, séparées par des rayons médullaires.

[1] J'emploie habituellement le mot *vaisseaux* pour indiquer ce tissu, quoiqu'il n'ait pas, ainsi qu'on le verra plus tard, les caractères des vrais vaisseaux. Ces tubes sont plutôt des utricules très-alongés et communiquant entre eux par leurs ouvertures latérales, comme les tubes fendus des Fougères et les tubes poreux qui forment le bois des Conifères, que de vrais vaisseaux dont les cavités seraient continues.

"Ces faisceaux, par leur contact presque immédiat, et la manière dont ils se correspondent avec une régularité parfaite, sont dans les mêmes rapports que les faisceaux fibro-vasculaires qui constituent le bois, proprement dit, dans les plantes dicotylédones, et les faisceaux de trachées qui, dans ces mêmes plantes, sont placés à la partie interne de ces faisceaux ligneux, et constituent l'étui médullaire. Aussi, quoique ces faisceaux internes n'aient pas exactement l'organisation et la disposition des faisceaux de trachées de l'étui médullaire, leur position, relativement aux autres parties, étant la même, je les désignerai sous le nom de faisceaux médullaires, pour les distinguer des faisceaux plus extérieurs, qui ont la structure rayonnante de la zone ligneuse, ce que j'appellerai les faisceaux ligneux.

"En dehors de ces derniers, on voit encore de petits faisceaux, dont la coupe transversale est arrondie, qui sont complétement isolés des faisceaux ligneux, mais qui en sont tantôt très-rapprochés, tantôt un peu plus éloignés, et qui correspondent exactement au milieu de chacun d'eux, puis enfin quelques-uns plus éloignés et disposés avec moins de régularité. Ces faisceaux sont, comme les faisceaux médullaires et ligneux, composés d'un tissu uniforme, mais plus fin, irrégulier et sans disposition rayonnante ; ils me paraissent avoir été isolés dans le tissu cellulaire extérieur, et n'être probablement que des faisceaux détachés du cylindre vasculaire et se portant dans les feuilles, mais qui ne seront conservés que dans la partie voisine de l'axe ligneux, tandis que la partie qui traversait obliquement la zone celluleuse extérieure aura été détruite, soit avant, soit pendant la pétrification, en même temps que le tissu cellulaire qui les environnait.

"Si nous examinons, au moyen de coupes longitudinales (pl. iii, fig. 2), ces mêmes parties vasculaires, dont je viens d'indiquer les positions respectives, telles que nous les offre la coupe transversale de la tige, nous verrons que tous les tissus conservés, et dont nous avons vu les orifices dans cette coupe, sont d'une structure très-analogue et ne présentent que de légères différences, qui peuvent échapper au premier coup d'œil, mais qui ne sont pas cependant sans quelque importance.

"Les faisceaux internes ou médullaires (pl. iii, fig. 2 *b b'*) sont composés d'utricules tubuleux très-allongés, très-inégaux en grosseur, dont les plus petits, *b'*, sont extérieurs, et les plus grands, *b*, sont placés au côté interne ; ces utricules, disposés sans régularité, assez flexueux, sont non seulement différents par leur grosseur, mais aussi par leur longueur.

"Les plus petits sont en même temps beaucoup plus courts, et leurs deux extrémités, terminées en cônes obtus, se présentent assez souvent simultanément dans le champ du microscope.

"Les plus gros, au contraire, sont aussi beaucoup plus allongés, mais cependant on les voit aussi se terminer par une extrémité close et arrondie.

"Les parois de ces utricules ont un caractère commun, c'est que toutes sont marquées de stries transversales ou spirales, très-nombreuses et assez fines, mais très-variables, soit de l'un à l'autre, soit dans les diverses parties de l'étendue d'une même utricule.

"Les plus gros (pl. iv, fig. 1 *b*), et ceux dont les angles sont les plus prononcés, présen-

tent en général des stries transversales, perpendiculaires à leur direction longitudinale ou peu obliqués, qui se réunissent entre elles dans les angles de ces utricules. Ils sont alors très-analogues aux vaisseaux rayés de beaucoup de Fougères et de Lycopodes, sauf quelques différences sur lesquelles je reviendrai plus tard.

"Dans d'autres utricules, généralement d'un moindre calibre, les stries ou raies sont beaucoup plus obliques, contournées en spirales, mais encore unies entre elles dans les points qui correspondent aux angles de ces utricules. Ces vaisseaux à raies obliques, *b′ b′*, passent très-fréquemment à une disposition réticulée très-régulière dans la plupart des cas, qui semblerait produite par deux ordres de stries obliques en sens inverse, et se croisant de manière à former un réseau à mailles rhomboïdales, ou devenant hexagonales par l'inflexion régulière de ces stries. Avec un faible grossissement, et par conséquent des lentilles d'un foyer moins limité, ou peut croire d'abord que l'on voit simultanément les stries spirales appartenant aux deux faces opposées d'un même utricule ; mais un grossissement plus considérable prouve que ces stries obliques en sens inverse sont tracées sur une même paroi, à moins toutefois qu'elles ne résultent de l'application très-intime des parois de deux utricules différents juxta-posés. La manière dont les fibres transversales passent aux fibres obliques, celles-ci à des fibres réticulées irrégulièrement, puis régulièrement (pl. iv, fig. 4), me fait cependant douter que cette explication soit exacte, et me porte à croire que ces diverses modifications s'opèrent dans les parois d'un seul et même utricule.

"Les utricules les plus petits de ces faisceaux, ceux qui sont situés vers la partie externe, et qui sont aussi moins étendus en longueur, offrent encore une troisième modification (pl. iv, fig. 1 *b″ b″* et *B*), à laquelle cependant on arrive insensiblement. Ils présentent de véritables fibres spirales continues, au nombre de 2, 3, ou 4, se contournant parallèlement les unes aux autres, sans aucune réticulation, exactement comme dans les trachées à fibres multiples, sauf la plus grande brièveté des utricules qui présentent cette structure, et l'espacement sensible des tours de spires, qui peut faire penser qu'ils étaient unis par une membrane appréciable, et qu'ils se rapportaient par conséquent plutôt à la modification qu'on a designée sous le nom de fausses trachées.

"L'intervalle qui sépare ces fibres, soit dans ces utricules à fibre spirale, soit dans ceux à fibres obliques ou réticulées, soit enfin dans ceux à fibres transversales, ne varie pas sensiblement dans un même utricule, mais varie notablement de l'un à l'autre ; il est moindre dans les utricules d'un petit calibre, à fibres généralement en spirale, et atteint son maximum dans les plus gros utricules, à fibres transversales ou peu obliques ; mais ces variations sont comprises entre $\frac{1}{300}$ et $\frac{1}{400}$ de millimètre. Si ces utricules, allongés et striés en spirale, ne sont pas de vraies trachées, on voit cependant qu'elles ont beaucoup d'analogie avec ces vaisseaux par l'obliquité et la disposition spirale de leurs fibres, et sont, pour ainsi dire, intermédiaires entre les trachées à spire multiple et les vaisseaux striés des Fougères et des Lycopodiacées. . . . . . .

"Ainsi, dans le *Lépidodendron Harcourtii*, dont j'ai pu examiner la structure dans tous

ses détails, grâce aux échantillons qui ont été donnés au Muséum par M. Hutton et par M. R. Brown, on voit qu'il y a, comme dans le *Sigillaria elegans,* un cylindre vasculaire excentrique, séparé de l'écorce par une large zone d'épaisseur inégale, d'un tissu cellulaire en partie détruit, et renfermant une masse celluleuse centrale également très-altérée. Au premier aspect il semblerait donc y avoir beaucoup d'analogie entre ces deux tiges, mais un examen plus attentif montre que la structure du cylindre vasculaire est tout-à-fait différente.

"Dans le *Lépidodendron Harcourtii* il n'y a aucune trace de rayons médullaires, et le tissu vasculaire n'affecte pas cette disposition en séries rayonnantes, qui parait presque toujours être la conséquence de l'existence des rayons médullaires. Ainsi, par la disposition des éléments qui le constituent, le cylindre vasculaire de ce Lépidodendron n'a aucune analogie avec le cylindre ligneux des *Sigillaria,* des *Stigmaria,* ou des *Anabathra,* mais cependant il est formé d'éléments semblables, c'est-à-dire de ces tubes prismatiques rayés transversalement qui constituent le tissu ligneux ou vasculaire de ces trois tiges, et il semblerait représenter le cercle interne ou médullaire de l'*Anabathra* ou du *Sigillaria,* si dans ce dernier on supposait que les divers faisceaux qui le constituent fussent réunis en un cylindre continu.

"De même que nous avons remarqué que les tiges du *Stigmaria* avaient tous les caractères essentiels de celles du *Sigillaria,* si on supprimait dans cette dernière les faisceaux médullaires, de même on peut dire que le cylindre vasculaire continu du *Lépidodendron Harcourtii* représente la zone vasculaire intérieure ou médullaire de l'*Anabathra* (en admettant que nos prévisions sur la nature soient exactes), dépouillée de la couche ligneuse et épaisse qui l'environne. N'y aurait-il pas dans le premier cas simplement la différence d'une tige à une racine, dans le second d'un jeune rameau chargé de feuilles à une tige plus âgée ? Cette dernière hypothèse me paraît cependant peu probable, à cause des prolongements vers l'extérieur que présente la zone vasculaire du *Lépidodendron Harcourtii* (pl. vi, fig. 5 *b'*; pl. vii, fig. 1 *b''*), prolongement dont on ne voit aucune trace sur la zone vasculaire interne de l'*Anabathra*."

5. Morris[1] (Roots).—In describing Mr. Prestwich's specimens Professor Morris says—"The portion of the stem of which the figure is a transverse section is in more perfect preservation than the specimens of *Stigmaria* usually are found in ; it is of nearly cylindrical form, about 4½ inches diameter, the external surface exhibiting the usual markings of this curious plant ; the internal part, with the exception of a vascular cylinder (also mineralised), being replaced by clay-ironstone."

Referring to the description of *Stigmaria* in the 'Fossil Flora,' Professor Morris states—"It has been thought advisable to have another section represented, with a view of showing what has hitherto not been well illustrated in the published figures of its structure. The internal cylinder in the specimen (fig. 3) is concentric, and consists of

[1] "On the Geology of Coalbrook Dale," by Joseph Prestwich, 'Transactions of the Geological Society of London,' 2nd series, vol. i, Explanation of Plates.

wedge-like portions of vascular tissue, the rounded origin of which, internally, is well defined; these wedges are generally of equal or nearly equal size, but they occasionally become confluent by the joining of two or more of them together. The form of the space necessarily left, or interstices between the sections where these are distinct, varies a little, in some cases being of nearly equal breadth throughout, and in others becoming narrower outwards and appearing to terminate or contract about the middle of the vascular tissue, beyond which they again frequently widen outwards: these spaces often contain portions of oblique and smaller vascular cords, apparently arising at different depths in the vertical cylinder, the origin and connection of which with the cylinder is shown in the oblique section, where a single series of vessels is seen passing from it surrounded by tissue of smaller diameter (pl. xxxviii, fig. 3 *a*).

"In no specimen yet examined has the course of the oblique cords been absolutely ascertained, but there can scarcely be any doubt, as suggested by Mr. Brown (to whom we are also indebted for the above observations), that these vessels, after arising from the cylinder, passed to the tubercles of the surface, through the thick cellular tissue which once probably occupied the larger space in the original plant. The discovery of these smaller oblique vessels is an interesting feature in the anatomy of *Stigmaria;* and they have also been pointed out by Mr. Brown as existing in *Anabathra;* and one of these is actually figured by Mr. Witham in his work (pl. viii, fig. 10), but considered by him (p. 41) as a section of a medullary ray. The analogous vessels existing in *Lepidodendron Harcourtii*, as figured by Mr. Witham ('Trans. Nat. Hist. Soc. Newcastle,' 1832), appear to arise from the outer part of the vascular cylinder. A somewhat similar division is found in that division of *Lycopodiaceæ* consisting of *Psilotum* and *Tmesepteris;* in those genera (according to Brongniart, 'Veg. Foss.,' vol. viii, pp. 44, 45) the vascular cylinder from which the oblique cords proceed includes a central pith."

6. Goeppert[1] (Roots) describes a very good specimen of *Stigmaria* with the pith containing vascular bundles, interspersed in cellular tissue, and the structure of the rootlets having an axis of vascular tubes, surrounded by cellular tissue. He appears to have been the first author to publish information on the structure of those portions of the root.

7. Binney[2] (Roots) describes the Fossil Trees having *Stigmaria* roots in Littler's quarry, near St. Helen's, Lancashire.

8. Binney and Harkness[3] (Roots).—Further observations on the last-named specimens.

9. Corda (Diploxylon).—Corda[4] describes the characters of his Diploxylon cycadeoidum:—"Truncus medullosus cylindricus; decorticatus extus longitudinaliter obscurè-

[1] 'Les Genres des Plantes fossiles,' Bonn, 1841.

[2] 'The London, Edinburgh, and Dublin Phil. Mag.,' ser. 3, vol. xxiv, p. 165, 1844.

[3] *Ibid.*, vol. xxvii, p. 241, 1845.

[4] 'Beiträge zur Flora der Vorwelt,' Prague, 1845.

striatus. Corpus corticale crassum medullosum. Cylindricus lignosus minutus, e stratis duplicibus compositus. Stratum internum continuum annuliforme, externo adpressum, vasis irregulariter positis amplis, sexangularibus. Stratum externum crassum, e vasis minutis seriatis et fasciculatim junctis compositum, et radiis vasorum ligni interni percursum. Radii medullaris nulli. Medulla ampla."

By the author's figure the medulla appears to be altogether wanting in the centre of the specimen; what it was composed of there is no evidence to show; it might have been parenchymatous tissue, or barred tubes. The vascular bundles shown traversing the woody cylinder, and their free communication with the inside medulla, and the rounded ends of such cylinder as well as the curved bundle of vascular tubes seen in the longitudinal section, show a considerable difference in structure from both *Diploxylon* and *Sigillaria vascularis* described by me in the 'Philosophical Transactions.'

10. King (*Sigillaria* and *Anabathra*).—Professor W. King,[1] in a most excellent paper entitled "Contributions towards establishing the General Characters of the Fossil Plants of the Genus *Sigillaria*," gave a lucid account of Brongniart's *Sigillaria*, showing its connection with *Stigmaria;* also some valuable original observations on specimens from Ouseburn, and North Biddick, proving that *Sigillaria* had a Stigmaroid root. His remarks on Mr. Witham's *Anabathra pulcherrima* show that its woody cylinder was identical in structure with that of *Sigillaria vascularis*, having been furnished with the sharp dark line separating it from the pith, without the interstices between the wedge-shaped bundles of the woody cylinder so distinctly shown in the Corda's *Diploxylon cycadoïdeum:*—

"Let us, in the next place, consider that remarkable fossil which Mr. Witham was the first to make known, under the name *Anabathra pulcherrima.* At the time when *Anabathra* was described few botanists had attended to the minute difference in vegetable tissue, which forms so conspicuous a feature in the phytological works of the present day; hence a few errors have been committed in drawing up the description which has been published of this fossil. Some of these errors have been rectified by M. Brongniart in his 'Observations on the Internal Structure of *Sigillaria elegans;*' but, as there are others which this gentleman had not the means of correcting, I have been induced to enter into the following description more minutely than would have been otherwise necessary. It requires also to be stated that, with the view of enabling me to become acquainted with the internal structure of fossil plants in general, Mr. Witham has, in the most handsome manner, placed in my hands the whole of his invaluable collection of sections, among which there is an instructive suite of *Anabathra.* To this gentleman, for so marked an act of kindness, there is certainly due from me an expression of deep obligation.

"Before commencing to describe the tissues of *Anabathra* it is necessary to make a slight reference to the state in which Mr. Witham's specimen existed when first dis-

[1] 'Edinburgh New Philosophical Journal,' vol. xxxviii, p. 119, 1845.

covered. It was invested with an irregular coat of mineral matter; in which were observed numerous small portions of vegetable tissue, intermixed with what appear to be twigs. Mr. Witham has represented this coat, charged with its vegetable fragments, in pl. viii, fig. 7, of his 'Internal Structure of Fossil Plants.' The matrix, as it ought rather to be called, was in immediate contact with the tissue of what we shall presently see is the ligneous zone of the fossil—a circumstance which prevents us coming to any conclusion as to the thickness of its bark; for instance, whether it was thin, like most of the Conifers, or thick, as is the case with the *Sigillariæ*, the Cycases and Cactuses. Mr. Witham, in his description, says that the specimen when complete was a tapering body several inches in length, rounded at the extremity, and resembling the termination of a stem or branch. In another part it is stated that the specimen, divested of its envelope, was compressed so as to have one diameter about a half greater than the other. 'At the lower part the large diameter was upwards of two inches; and at the extremity one diameter is about half an inch, the other nearly a fourth.' I may observe that the sections before me answer to these and the intermediate sizes. If we were uncertain that *Anabathra* possessed a thick bark, there is something in the description just quoted which would induce one to suppose that this fossil was a short fleshy plant, resembling some of the Cactuses. Let it be understood, however, that I am far from thinking that this was the case. Mr. Witham states that the specimen presented the appearance of natural joints at the distance of about two inches, and that its surface was slightly striated in the longitudinal direction. I mention these circumstances merely to give it as my opinion that the striated appearance was caused by the very elongated tubes of the ligneous zone, and that the joints were simply transverse cracks.

"A very singular result has been brought about by mineralisation in Mr. Witham's specimen. A large portion of the radiated tissue has been destroyed; what remains is contained in a narrow marginal strip and in numerous isolated pea-shaped bodies, imbedded in a crystalline matrix, and situated inwardly to the latter. The reader is therefore requested to fill up in imagination all the vacant spaces which are represented in figs. 2 and 3 of pl. iv, and with the same kind of tissue as that which forms the marginal strip and the isolated bodies. To aid this a transverse restoration of the vascular and ligneous system is given in fig. 1, which is a little above the natural size.

"*Anabathra pulcherrima* is undoubtedly a dicotyledonous plant. It possesses a broad ligneous zone (*a*, fig. 1, pl. iv), a large medullary sheath in the shape of a hollow cylinder (*b*), and apparently a large pith (*c*). The ligneous tissue consists of very much elongated tubes which are occasionally quadrilateral, but generally hexagonal; they are arranged in radiating series, and are remarkably regular in diameter throughout the thickness of the zone, till within the precincts of the vascular cylinder, where they become considerably reduced. The apertures caused by sectionising these tubes are distinctly seen with a common magnifier. Their length appears to be considerable, since a longitudinal section nearly half an inch long shows none of the tubes with both

terminations (see figs. 3 and 4). The whole of their walls are marked with fine transverse lines or bars, which in general are parallel to each other; but occasionally they divide as is represented in fig. 5. All the tubes have their walls of a uniform thickness, so that *Anabathra* displays no appearance of the concentric rings which are found in the wood of ordinary exogenous trees. The ligneous zone appears to have been intersected by numerous narrow medullary rays, judging from the interspaces which are marked *d* in figs 2 and 4.

"The vascular cylinder is composed of elongated tubes which on the transverse section are irregularly angular, and somewhat variable in their proportion. Those of the greatest diameter are a little larger than the tubes composing the marginal strip of the ligneous zone, and they constitute the inner four fifths of the cylinder; while the smallest, into which the others gradually pass, occupy the remaining or outer portion. At the margin of the cylinder the vessels have become so diminished in size as to resemble the small ligneous tubes which immediately circumscribe them; occasionally a small vessel is to be seen among the larger ones. With the exception of their being placed somewhat according to size, as just stated, the tubes of the medullary sheath possess no order in their arrangement. The tissue of this part appears to be shorter than that of the ligneous zone, as there are several terminations displayed on a longitudinal section (see *b*, fig. 3); but I am strongly inclined to believe that the shortness is more apparent than real: it ought rather to be said that the tubes in their longitudinal direction are very flexuous and twisted round each other. This circumstance, by causing a longitudinal section to display certain of the tubes obliquely cut, and others deviating from each side of the plane of the section would produce, it is conceived, the appearance as if these cuts and deviations were so many terminations. The walls of the tubes are marked with transverse lines or bars, which differ somewhat from those on the ligneous tissue, inasmuch as they are closer to each other, and they are often seen coming in contact, which gives them an anastomosed appearance (see fig. 6, pl. iv). In none of the large vascular tubes are the lines so disposed as to form a spiral, either broken or continuous; probably this is the case in the smallest, but the section is not sufficiently thin to allow of its being seen. The vascular cylinder is in close contact with the ligneous zone; and in no part does it display the least appearance of openings or medullary rays.

"The pith appears to have been formed of fusiform cells, analogous to those which Brongniart describes as belonging to the corresponding part of *Lepidodendron*. It may be doubted, however, that what I have considered as forming a portion of the pith of *Anabathra* did in reality belong to this part, since it is simply a portion of fusiform tissue crossing the centre of one of the transverse sections.

"Reverting to the ligneous tissue, and adverting to the longitudinal section represented in fig. 4, pl. iv, which is at right angles to the medullary rays, and through the marginal strip, our attention must now be directed to these large openings (*c*) which

form so prominent a feature. There are only two represented, owing to a greater number requiring more space than could be allotted for the figure; it consequently requires to be stated that they are arranged in a spiral manner. Mr. Witham described these openings as containing the medullary rays, which is not the case, because what has been probably taken for cellular tissue is in reality a number of small vessels (*f*) similar to those which occupy the outer part of the medullary sheath. Although the longitudinal sections do not exhibit any of these bundles springing from the vascular cylinder, their proximity to this part in some transverse sections (see fig. 2), together with the fact just stated, leaves no room to doubt their having constituted the leaf-cords of the plant. According to Mr. Morris it would appear that Dr. Brown had ascertained this point some time since.[1] Owing to one of the openings, or vascular passages, having been intersected in a portion of its course through the ligneous zone, as shown in the longitudinal section parallel to the medullary rays in fig. 3, pl. iv, we have displayed in a very instructive manner a leaf-cord, or vascular bundle (*f*), traversing at right angles the ligneous tissue; a similar bundle is exhibited in the transverse section (fig. 2). These two sections prove that the leaf-cords curve but very slightly in their passage through the ligneous zone, as they proceed horizontally for a considerable distance. From the passage being in part hollow (see fig. 4), it may reasonably be supposed that the cords were accompanied in their course with a portion of cellular tissue.

"We may now be permitted to say a few words on the comparative anatomy of *Anabathra*. No one can help being struck with the similarity which this plant possesses in some points of its structure to *Sigillaria* and *Lepidodendron*. The width of the ligneous zone is certainly greater in *Anabathra* than in *Sigillaria;* but there scarcely appears to be a shade of difference in the character of its constituent tissue in either plant; while between *Lepidodendron* and *Anabathra* there is in their vascular cylinder the closest resemblance. It is, therefore, clear that these three plants are nearly related to each other.

"The resemblance between *Anabathra* and *Lepidodendron* in their vascular cylinder has induced Brongniart to hazard a question to this effect: May not the latter be the young branch, and the former the stem, of one and the same plant? 'The hypothesis involved in this question,' says its author, 'appears, however, to have little probability in its favour, in consequence of there being on the outer part of the vascular cylinder of *Anabathra* none of the prolongations which are visible on the corresponding part of *Lepidodendron*.' The prolongations here alluded to are those portions of the leaf-cords which are on the point of curving off from the cylinder, to the margin of which they give a sinuous appearance. Mr. Witham's transverse sections of *Anabathra* certainly do not show any sinuosities. Brongniart's objection is, therefore, so far a valid one; but it seems to me that, before *Lepidodendron* can be considered as the branch of *Anabathra*,

[1] 'Transact. Geological Society,' 2nd series, vol. v, description of pl. xxxviii. See above, p. 113.

there is required to be known an example of a Dicotyledonous tree having young branches without any radically arranged ligneous tissue.

"*Sigillaria elegans* possesses in its anatomy a peculiarity of considerable interest in a physiological point of view. It is furnished with a medullary sheath, which, there is a strong reason to believe, existed to a certain degree independently of the ligneous zone. But whatever doubt might stand in the way of such a peculiarity possessing itself of our own conviction, so far as *Sigillaria* is concerned, it is clearly demonstrated by what is observable in *Lepidodendron* and *Anabathra,* inasmuch as in the former the vascular cylinder has performed its function without the presence of the ligneous zone of the latter; add to this, that in *Anabathra,* although these two parts are in immediate contact with each other, the differences which have been pointed out in their respective tissues further prove that they represent independent systems. It will now be seen on what grounds the distinction has been made in this paper between the vascular and the ligneous part of the fossils which have been mentioned."

11. BINNEY[1] (Roots).—Description of the Dukinfield *Sigillaria* with long *Stigmaria* roots, showing how the latter change their characters as they extend outwards from the tree.

12. BROWN[2] (Roots.)—In a paper on a group of fossil trees, in the Sydney Coal-field of Cape Breton, with *Stigmaria* roots.

13. BINNEY[3] (Roots).—Description of *Sigillaria reniformis* having *Stigmaria ficoides* as its roots, from the Pemberton Hill Cutting, on the Bolton and Liverpool Railway.

14. HOOKER[4] (Roots).—Dr. Hooker describes *Stigmaria* with close wedges in the woody cylinder, as well as one with open wedges, and shows that these two different roots belong to specimens having the same external characters. He also notices the depth of the bell-shaped cavities from which the rootlets proceed.

15. BROWN[5] (Roots).—Description of an upright *Lepidodendron* with *Stigmaria* roots in the Sydney Main Coal, in the Island of Cape Breton.

16. BROWN[6] (Roots).—Description of a *Sigillaria,* with conical tap-roots found in the Sydney Main Coal.

17. BRONGNIART[7] classes under *Dicotylédones gymnospermes* the family *Sigillariées,* containing the genera *Sigillaria, Stigmaria, Syringodendron, Diploxylon, Ancistrophyllum?* and *Didimophyllum?* and considers that Witham's *Anabathra* and Corda's *Diploxylon* belong to the same genus. The same author, in treating on the *Diploxylon* of Corda, writes:[8] "Ce genre n'est connu que par sa structure interne, qui me parait se rapprocher du *Sigillaria,* dont il diffère cependant par le cylindre continu, formé par

[1] 'Quarterly Journal Geol. Soc.,' vol. ii, p. 391, 1846.

[2] *Ibid.*, p. 393, 1846.

[3] 'Phil. Mag.,' s. 3, vol. xxvii, p. 259, 1847.

[4] 'Memoirs of the Geological Survey,' vol. ii, part ii, p. 431, &c., 1848.

[5] 'Quarterly Journal Geol. Soc.,' vol. iv, p. 46, 1848. [6] *Ibid.*, vol. v, p. 354, 1849.

[7] 'Tableau de Végétaux fossiles,' p. 97, 1849. (Ext. Dic. univ. d'Hist. Nat.)

[8] *Ibid.*, p. 57.

les vaisseaux qui environnent la moëlle et, suivant M. Corda, par l'absence de rayons médullaires. M. Corda ne rapporte à ce genre qu'une seule espèce, le *Diploxylon cycadoïdeum,* décrite par lui, et trouvée dans le terrain houiller de Chomle, en Bohème; mais je crois que c'est à ce même genre qui appartient, sans aucun doute, l'*Anabathra pulcherrima* de Witham ('Int. Struct. of Foss. Veg.,' p. 40, pl. 8), et je me fonde pour cela sur d'excellentes coupes de ce fossile remarquable, qui m'ont été adressées par ce savant, et qui montrent que le tissu qui entourne la moëlle détruite, mais dont on voit quelque trace, forme un cylindre continu sans direction rayonnante, et composé de vaisseaux rayés disposés comme dans *Diploxylon.* C'est une seconde espèce de ce genre, à moins qu'on ne croie devoir réserver à ce groupe le nom d'*Anabathra.*"

18. Binney[1] alludes to the occurrence of spores in the inside of *Stigmaria,* and notices the remarkable crucial sutures on the base of the stems of some *Sigillariæ.*

19. Dawson[2] (Roots), in his description of the Coal-measures of South Joggins, Nova Scotia, alludes to *Sigillaria* having *Stigmaria* roots.

20. Goldenberg[3] describes and figures spherical bodies, some with a triradiate ridge, and others without that character, as the fruit of *Sigillaria, Stigmaria,* and fossil *Selaginæ.* These bodies, according to the author, appear to be attached to the scales of the cones, and not contained in a sporangium; and in the figures they appear chiefly at the base of the specimen.

21. Binney[4] (Roots) gives information as to the origin of the medullary rays, and the nature of the vascular bundles, in the pith of *Stigmaria,* also as to the structure of its radicles.

22. Binney[5] on *Sigillaria* and its roots.

23. Binney[6] (*Sigillaria* and *Stigmaria*):—" In the present paper it is my intention to confine myself to the description of three specimens of fossil plants which would generally have been designated *Lepidodendron* in England and *Sagenaria* on the Continent.

" No. 1.—The specimen illustrated in pl. iv consists of a cylindrical stem $\frac{8}{10}$ths of an inch in diameter, nearly enveloped in its stony matrix, and only showing its external characters on one side. These consist of rhomboidal scars of an elongated and somewhat irregular form, arranged in quincuncial order, but not so perfectly as seen in most species of *Lepidodendron.* In the middle of each scar there is an oval depression, from which rises a rounded prominence, where the leaf was attached. The scars resemble those of *Lepidodendron selaginoides,* figured by Messrs. Lindley and Hutton in their 'Fossil Flora,' vol. i, fig, 12, but the depression in the scar on their specimen is not so marked as in mine.

1 'Quart. Journ. Geol. Soc.,' vol. x, p. 1, 1854.
2 Ibid., vol. vi, p. 17, 1849.
3 'Flora Saræpontana fossilis,' pl. B, figs. 18 to 25 (1855), pl. x, figs. 1 and 2 (1857).
4 'Quart. Journ. Geol. Soc.,' vol. xv, p. 76, 1858.
5 'Trans. Manchester Geological Soc.,' vol. iii, p. 110, 1861.
6 'Quart. Journal Geol. Soc.,' vol. xviii, p. 107, &c., 1862.

"In the middle of the large cylinder last described is a smaller one, about $\frac{1}{7}$th of an inch in diameter. This is composed of large hexagonal vessels, of irregular sizes (*a, a*), placed one beside the other, without order, but becoming smaller as they approach the circumference, all having their sides barred with transverse striæ, and some of the smaller ones (*a, a*) being divided at short intervals by horizontal and oblique partitions. The outside of this inner cylinder[1] (*b, b*) is composed of hexagonal cells, barred with transverse striæ, about $\frac{1}{6}$th of the diameter of those contained in the centre, arranged in radiating series of a wedge shape, and divided by medullary rays or vessels very finely barred (*c, c*) as in the vascular cylinders of *Sigillaria* and *Stigmaria,* respectively described by Brongniart and Hooker. Around and placed next to the cylinder are a number of round bundles of fine vascular tissue (*d, d*), some of which are opposite to the medullary rays or vessels, and others apparently away from them, near the wedges of the wood. These bundles seem to be connected with the vessels which supply the leaves, but cannot be well traced to the medullary rays in all cases. It is probable that they may be sections of vessels passing from the medullary rays, or vessels, to the leaves. They are evidently the same vessels as are figured by Messrs. Lindley and Hutton ('Fossil Flora,' vol. ii, Pl. 99, fig. 1), and also resemble the vessels described by Brongniart as occurring on the outside of the woody cylinder in *Sigillaria elegans.* On the external portion of the outer radiating cylinder of the specimen similar vessels can be distinctly traced into the projecting scars from whence the leaves arise.

"Next occurs a space of about $\frac{4}{10}$ths of an inch (*e, e*), in which the tissue has for the most part disappeared and been replaced by mineral matter; but it seems to have been composed of delicate cellular tissue, which was traversed by bundles of vessels leading from the axis to the leaves. Then comes a zone of coarse cellular tissue (*f, f*) which gradually passes into small elongated utricles, of hexagonal form, and arranged in radiating series, which probably formed the inner bark. These in their turn pass into a black carbonaceous matter (*h, h*), the remains of the outer bark of the tree. The vessels traversing the external cylinder are of the same character as those traversing the internal one, except that they are of much greater size, each of the latter being probably composed of two or more of the former, as Dr. Hooker describes in *Sigillaria.*[2] A transverse section of the specimen 'No. 1' is similar to the same section of *Sigillaria elegans,* with this exception, namely, that the inner lunette-shaped bundles of vessels found within and next to the woody cylinder in M. Brongniart's specimen fill the whole of the central axis in mine. At first sight it might have been supposed that the specimen of *Sigillaria elegans* beforenamed had some of its middle portion destroyed, and that the lunette-shaped bundles once occupied the whole of the central axis; but having by the kindness of M. Brongniart been permitted to examine the original specimen preserved in the

[1] "In this specimen by some cause a portion of the inner cylinder has been destroyed, either by the section not being cut true or by a part of the woody cylinder having been destroyed in calcification."

[2] "'Memoirs of the Geological Survey of Great Britain,' vol. i, part ii, p. 436."

Museum of the Jardin des Plantes, it appears to me that the learned author's description of the specimen, as well as the figure in the plate, are both remarkably correct. Although his specimen does not show the external structure of large *Sigillariæ*, my own observations lead me to the conclusion that we shall find the latter very much resembling, if not altogether identical in structure with, *Sigillaria elegans*. In large specimens of *S. reniformis* and *S. organum*, whose structure is preserved in my own cabinet, there is distinct evidence of the internal cortical envelope, formed of elongated cellular tissue, or utricles, and disposed in radiating series, in all respects like that described by M. Brongniart in his Autun specimen.

"The longitudinal and tangential sections of my specimen show that the vessels of the central axis and the woody cylinder are barred transversely on all their sides. M. Brongniart found this to be the case with *Sigillaria*, and gives it as characteristic of *Sigillaria*, *Stigmaria*, and *Anabathra*.[1] Specimens of these three, now in my cabinet, clearly prove that their central axes and their woody cylinders are exactly the same in structure and arrangement; thus affording evidence, from structure, that *Stigmaria* is the root of *Sigillaria*, and that *Anabathra* is a *Sigillaria*—which has long been expected would prove to be the case."

24. Binney[2] (*Diploxylon*):—"This specimen [No. 1] is not in so perfect a state of preservation as those fossil woods intended to be hereinafter described in this communication, especially as regards its central and external parts; but it certainly differs from them in having a larger mass of scalariform tissue composing the central axis, and having the inner portion of the wedge-shaped bundles forming the internal radiating cylinder of a convex shape as they approach the central axis, somewhat like those represented by Brongniart in his *Sigillaria elegans*, and still more resembling those described by Corda in *Diploxylon cycadoïdeum*; but my specimen shows within those convex bundles a broad zone of scalariform tissue, arranged without order, and marked with transverse striæ.

"It has been assumed, both by Corda and Brongniart, that *Diploxylon* had a pith composed of cellular tissue, surrounded by a medullary sheath of hexagonal vessels, arranged without order, barred on all their sides with transverse striæ. My specimen is evidently more complete in structure than those of the last-mentioned authors, or even that which Witham himself described; but, although it shows the so-called medullary sheath in a very perfect state, there is nothing to indicate the former existence of a pith of cellular tissue. All the specimens examined by Witham, Corda, and Brongniart appear to have had their central axes removed altogether, and replaced by mineral matter, or else only showing slight traces of their structure; and these authors appear to have inferred the former existence of a pith of cellular tissue, rather than to have had any direct evidence of it in the specimens of *Anabathra*, *Diploxylon*, and *Sigillaria*

[1] "'Extrait des Archives du Muséum d'Histoire Naturelle,' p. 429, Paris, 1839."

[2] 'Phil. Transactions,' vol. 155, p. 583, 1865.

respectively figured by them. Every collector of Coal-plants is aware of the blank space so generally left in the above fossil plants, as well as in the roots *Stigmariæ*. It is quite true that a little disarrangement of the scalariform vessels (a') in the specimen is seen; but the part which remains undisturbed shows that the whole of the central axis was formerly composed of hexagonal vessels [tubes], arranged without order, having all their sides marked with transverse striæ, and not of cellular tissue. This view is confirmed by another and more perfect specimen of *Anabathra* [*Diploxylon*] in my cabinet, and enables me to speak with positive certainty, and to show that these three plants had a similar structure in the central axes to the specimens of *Sigillaria vascularis* described by me in my paper published in the 'Quarterly Journal of the Geological Society.'

"My specimen clearly proves the existence of medullary rays or bundles traversing the internal woody cylinder, which originate on the outside of the central axis; and it appears to me pretty certain that Corda's specimen of *Diploxylon cycadoideum*, if tangential sections had been made and carefully examined, would have done the same.

"The exterior of the specimen is not in a complete state of preservation, but it seems to have been covered by irregular ribs and furrows, with slight indications of the remains of the cicatrices of leaf-scars. Its marked character, as previously alluded to, is the great space occupied by the central axis. This is of much larger size than in either the *Sigillaria vascularis* or the specimens intended to be next described.

"The lunette-shaped ends of the wedge-like bundles of the inner woody cylinder bear some resemblance to the form of the same parts of the *Sigillaria elegans* of Brongniart; but much more to those of Corda's *Diploxyylon cycadoideum*, with which it appears to be identical. . . . .

"As Brongniart has preferred Corda's name of *Diploxylon* to *Anabathra*, and as the former is a more expressive generic name, in my opinion, probably it is better to adopt it, and accordingly the specimen has been denominated *Diploxylon cycadoideum*."

25. Binney[1] (*Sigillaria*):—"Fig. 2 shows the outside appearance of the specimen marked with fine longitudinal striæ, irregular ribs and furrows, and some cicatrices of leaf-scars, which would induce most collectors of Coal-plants to class it with a decorticated specimen of *Sigillaria*. It most resembles *Sigillaria organum*. The bark of a portion of the specimen remains attached to it in the form of coal that is united to the matrix of the seam in which the fossil was found embedded. The reverse side of the specimen does not show the character so distinctly.

"Here we have a *Stigmaria*-like woody cylinder, with a central axis composed of barred vessels arranged without order, found in the inside of a stem of *Sigillaria* in such a position as it existed in the living plant. It is not a solitary instance, but one of more than fifty specimens exhibiting similar characters which have come under my observation.

"In pl. xxxii, fig. 1, is represented the light-coloured disk previously alluded to and

[1] Op. cit., p. 586, &c., 1865.

shown in pl. xxxi of the natural size, but here magnified 5 diameters, exhibiting the central axis composed of hexagonal vessels arranged without order, of several sizes, those in the middle being smaller, and becoming larger towards the outside, where they come in contact with the internal radiating cylinder, *b*, and then again diminishing in size. This latter was no doubt cylindrical, like the stem of the plant; but both parts in the process of petrification have been altered by pressure to their present forms. It consists of a broad cylinder, *b*, about an inch in diameter, composed of parallel elongated tetragonal or hexagonal tubes, of equal diameter throughout for the greater part of their length, obtuse and rounded at either extremity, and everywhere marked with crowded parallel lines, which are free or anastomosing all over the surface. The tubes towards the axis are of the smallest diameter; they gradually enlarge towards the circumference, where the largest are situated, though bundles of smaller tubes occasionally occur among the larger. This cylinder, which, for convenience, may be called the internal woody system of the plant, is divided into elongated wedge-shaped masses, pointed at their posterior or inner extremity, and parted by fine medullary rays, of various breadths, some much narrower than the diameter of the tubes, others considerably broader; but none are conspicuous to the naked eye, except towards the outer circumference in some rare instances.

"Fig. 2 represents a transverse section of the central axis and the commencement of the internal radiating cylinder, magnified 12 diameters. The hexagonal vessels in the centre and at the circumference, where they come in contact with the internal radiating cylinder, are smaller in size than those seen in the other parts of the axis. The dark line across the axis, as well as the dark space in the centre, both seem to be the result of a disarrangement of the tubes during the process of mineralization, as similar appearances have not been observed in many other specimens examined by me, which in those parts are in a more perfect state of preservation. The dark and sharp line separating the vessels of the central axis from those of the internal radiating cylinder does not permit us to clearly see the origin of the medullary rays or bundles which undoubtedly traverse the latter.

"Fig. 3 represents a longitudinal section taken on the right-hand side of the specimen, and extending across the whole of the internal radiating cylinder, through the central axis, the intermediate space between the internal radiating cylinder and the outer cylinder, and the external radiating cylinder, to the outside of the stem, magnified 4 diameters; *a, a* showing the smaller barred vessels of the central axis, having some (*a′, a′*) which appear to have been disarranged; *b, b* the internal radiating cylinder of larger barred vessels; *c* the space occupied by lax cellular tissue, traversed by bundles of vessels; and *d* the external radiating cylinder, consisting of elongated tubes, or utricles, arranged in radiating series, diverging from certain circular openings, and divided by masses of muriform tissue, which contain the medullary rays or bundles.

"Fig. 4 is a tangential section of the same parts of the specimen as lastly described,

magnified 4 diameters; b', b' showing the medullary rays or bundles traversing the inner radiating cylinder, and d', d' those traversing the outer radiating cylinder.

"Pl. xxxiii, fig. 1, is a longitudinal section of a portion of the same specimen, exhibiting the central axis [1] and the inner radiating cylinder, magnified 15 diameters. Fig. 2 shows several of the vessels of the central axis, as they would be if they were not ground away in the operations of slicing and polishing, magnified 45 diameters. Fig. 3 is a tangential section of the inner radiating cylinder; b showing the barred vessels, and b'' the medullary rays or bundles, magnified 15 diameters. Figs. 4 and 5, longitudinal and tangential sections of the same specimens, showing the structure of the outer radiating cylinder; d denoting the tubes, or elongated utricles, of which it is composed, and d' the medullary rays or bundles which traverse it, magnified 10 diameters.

"Pl. xxxvi, fig. 1, represents a transverse section of a ribbed and furrowed stem ('No. 3'), displaying similar cicatrices to that of 'No. 2,' given in pl. xxxi, and having a like central axis, as well as like internal and external radiating cylinders and other parts, magnified 2 diameters. It is given for the purpose of more distinctly showing the tubes or elongated utricles, d, and the fusiform openings formed of very open muriform tissue, d', enclosing the medullary rays or bundles which traverse the external radiating cylinder; this it does in a very marked manner; magnified 20 diameters.

"In pl. xxxv, figs. 1, 2, and 3 ('Nos. 4, 5, and 6'), are shown the exteriors of three central axes, separated from large-ribbed-and-furrowed stems, in every respect similar to those described in pl. xxxi, and pl. xxxiv; and such as might easily be taken for small *Calamites;* magnified $2\frac{1}{2}$ diameters. Fig 4 ('No. 7') shows the outside of the internal woody cylinder of a *Stigmaria*, with ribbed and furrowed characters, resembling those shown on the outsides of the central axes lastly described; also magnified $2\frac{1}{2}$ diameters. The first three specimens, 'Nos. 4, 5, and 6,' are from the Halifax 'Hard Seam' of coal, at South Owram; but 'No. 7' is from the Wigan "Five-feet Mine," a seam in the Middle Coal-measures. The tangential sections which show the medullary rays, or bundles that traverse the inner and outer radiating cylinders, afford clear evidence of the different appearance of the bundles marked b'' in pl. xxxiii, fig. 3, from those in pl. xxxiv, fig. 2, marked d'.

"Specimens 'Nos. 2 and 3' bear considerable resemblance to the *Sigillaria elegans* of Brongniart, with respect to their internal radiating cylinder and the medullary rays or bundles which traverse it, assuming that such vessels come from the outside of the central axis, and not from the exterior of the internal radiating cylinder, as that distinguished savant supposed. Certainly there is no evidence in my specimens to support the latter view. A great many specimens have been broken up and destroyed for the

[1] "In the plate the small tubes a', a'' appear to be divided by septa. This is certainly the case in one slice; but in another of the same specimen these septa are not seen, but small barred vessels appear in their places, so the former may probably be due to the direction of the slice being cut along the dark line which traverses the central axis, as shown in pl. xxxii, figs. 1 and 2."

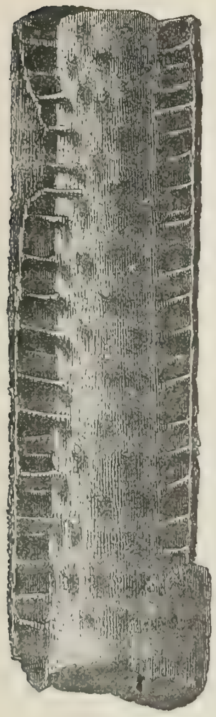
purpose of examining the inner radiating cylinder, and in every case medullary rays or bundles were found traversing it, just as you find in the same part of *Stigmaria*. On the outside of the inner cylinder, at the extreme part of the zone of coarse and lax cellular tissue which bounds it, are some circular openings from which spring the wedge-shaped masses of quadrangular, tubular, or elongated utricles which form the outer radiating cylinder. The lax cellular tissue has nearly always been displaced and disarranged in the process of mineralization, and sometimes the outer radiating cylinder, and the circular orifices connected with it, have been pushed towards the inner cylinder. This may be the case in Brongniart's specimen, and have caused him to suppose that the medullary rays or bundles originated only on the outside, and were not joined to those which traversed the inner cylinder. So far as my larger specimens show there were medullary rays, which had their origin next the central axis, passed through the inner cylinder, and, after traversing the zone of lax cellular tissue outside the latter, apparently communicated with similar rays or bundles of vessels of much larger size, which are always found traversing the outer radiating cylinder, and then went on to the leaves on the outside of the stem. . . . . .

"In the specimens Nos. 2 and 3 the outer radiating cylinders are nearly an inch and a half in breadth, of thick-walled tubes or elongated utricles arranged in radiating series and diverging from a circular opening; while in Brongniart's *Sigillaria elegans* the outer radiating cylinder was not more than $\frac{1}{12}$th of that breadth. Probably my specimens may not prove to be of the same species as that of the celebrated Autun specimen; still they may be of the same genus, although of considerably greater age. But they have the greatest resemblance to the *Sigillaria vascularis* described by me in a paper read before the Geological Society and printed in its 'Journal' (vol. xv, p. 636). All the specimens described in that communication, as well as those in the present, were obtained by me from the same seam of coal, but at different places; still the two, namely the large-ribbed-and-furrowed specimens and the small rhomboidal-scarred stems, are always found associated together, and they can be traced gradually passing from one into the other. These facts, when taken in connection with the similarity in structure in the central axis, the internal radiating cylinder, the space filled with lax cellular tissue between the latter and the outer radiating cylinder diverging from circular openings, clearly prove that the smaller specimen is but the young branch of the older stem 'No. 2.' It is true that the earlier authors who have written on these plants would scarcely have admitted a ribbed and furrowed *Sigillaria* to have been so intimately connected with a rhomboidal-scarred plant, but it is now generally allowed that such differences in external characters would afford no grounds for ignoring the structural similarity of the specimens. Undoubtedly the small *Sigillaria vascularis* was part of a branching stem, for in my cabinet there is a specimen clearly showing two internal radiating cylinders just at the point where the branches dichotomized, as shown in the woodcut (fig. 2), so often met with in *Lepidodendron*.[1] . . . . .

[1] See Plate XIV, fig. 4, of this Monograph.

"The broad space intervening between the internal and external radiating cylinders, filled with lax cellular tissue and traversed by medullary bundles communicating with the leaves on the outside of the stem, as shown in the specimens described in this paper, is the only part on which information is required to complete our knowledge of the structure of the stem of *Sigillaria*. Fortunately a small specimen of *Sigillaria vascularis*, kindly presented to me by Mr. Ward, of Longton, a most indefatigable collector, has enabled me to obtain considerable information on this point. This specimen shows the rhomboidal scars on the outside of the stem, the two radiating cylinders, and the space between occupied by lax cellular tissue and traversed by medullary bundles.

FIG. 4.



Sigillaria vascularis.

"The specimen in this woodcut[1] (fig. 5 [fig. 4], magnified twice) is of smaller size than any previously described by me, but it is, from both its internal structure and external characters, a small *Sigillaria vascularis* in its young state, when the two radiating cylinders, especially the outer one, of the plant were only slightly developed. The medullary rays are seen on the outside of the inner radiating cylinder, and pass, inclining upwards at a small angle, from the inner cylinder to nearly the outside of the stem. No trace of the outer cylinder can be seen, so as to enable us to see whether the smaller-sized medullary bundles, coming from the inner cylinder, join the larger ones in the outer cylinder, described in pl. xxxiv, fig. 2, and there marked *d′*. All the tangential sections show the medullary bundles, both in large and small specimens, to be much greater and stronger in the outer than in the inner radiating cylinder; but no evidence has yet been found of the junction of these medullary bundles to prove that the former run into the latter, or whether the two are distinct. They consist of hexagonal tubes, barred on all their sides, surrounded by muriform tissue, that on the outside of the specimen being of very coarse texture."[2]

[1] Obligingly lent by the Council of the Royal Society.

[2] In all the large and small specimens of *Sigillaria vascularis* which have come under my observation that illustrated by this woodcut is the only one that clearly shows the vascular or foliar bundles proceeding direct from the outside of the inner radiating cylinder to the leaf-scars. This, from recent investigations, has been known to be the case. On its outside it is covered with rhomboidal scars like all the small specimens. The space intervening between the inner radiating cylinder and the outer one appears to have once consisted of iron-pyrites, which has since been decomposed, leaving the vascular or foliar bundles fully exposed. On comparing the direction which these organs take, from the inner to the outer radiating cylinder, with those shown in the specimen "No. 31," Plate XIII, figs. 2 and 3, of *Lepidodendron Harcourtii* in this Monograph, it will be seen that they run in nearly a horizontal direction, compared with the high angle the latter make when proceeding from the stem. This difference in the direction of the vascular or foliar bundles in *Lepidodendron* and *Sigillaria vascularis* is very marked, and worthy of the attention of those authors who contend that the latter plant is only a *Lepidodendron*.—E. W. B.

26. Binney[1] (*Stigmaria*):—"Many years since, after an examination of a great number of specimens of *Stigmaria* in my collection, it occurred to me that an outer radiating cylinder would ultimately be discovered. In my remarks on *Stigmaria*[2] is the following passage:—'That part of *Stigmaria* which intervened between the vascular axis and the bark appears to have consisted of two different kinds of cellular tissue. These in most cases have been unfortunately destroyed, so that we cannot positively know their true nature; but they appear to be of different characters, for there generally appears to be a well-marked division. This is often shown in specimens composed of clay-ironstone which have not been flattened, and the boundary-line is generally about a quarter of an inch from the outside of the specimen. More probably the outer part of the zone has been composed of stronger tissue than the inner one, as is the case with well-preserved specimens of *Lepidodendron*.' It is singular that Drs. Lindley and Hooker, as well as such acute observers as Brongniart and Göppert, had not noticed this line of division; but this was, no doubt, owing to the imperfect specimens they had examined. After the discovery of the outer radiating cylinder by Witham in *Lepidodendron*, and the same arrangement in *Sigillaria* by Brongniart, it was to be expected that such outer radiating cylinder would be found to occur in *Stigmaria*, if it were the root of *Sigillaria*. After an inspection of a great number of specimens, the cabinet of Mr. Russell, of Chapel Hall, Airdrie, has afforded me four or five distinct specimens which give clear evidence of the existence of this outer radiating cylinder in *Stigmaria*. They are all in clay-ironstone, and have not been much compressed. He has kindly allowed me to slice two of the specimens, which afford decisive evidence of the former existence of both an inner and an outer radiating cylinder. The space on the outside of the inner cylinder does not distinctly show the bundles of vessels communicating with the rootlets, although there is some evidence of their former existence. The bell-shaped orifices from which the rootlets spring are well displayed, and the space between them is occupied by wedge-shaped masses of tubes or elongated utricles arranged in radiating series, and not to be distinguished in any way from those shown in pl. xxxv, fig. 5. Indeed, the transverse section of the specimens there figured

Fig. 5.

Section of *Stigmaria*, from Airdrie.

[1] 'Phil. Trans.,' vol. clv, 1865, p. 592.

[2] 'Quarterly Journal of the Geological Society,' vol. vi, p. 20.

[3] For this and the preceding woodcut I am indebted to the Council of the Royal Society, who have kindly lent me the blocks.

would almost do for a representation of the *Stigmaria*, if the latter had the central axis preserved, which it unfortunately has not. There is the same internal radiating cylinder, the same space occupied by lax cellular tissue, which gradually passes into tubes or elongated utricles, arranged in radiating series, apparently diverging from circular openings, and parted by large bundles of muriform tissue containing vessels barred on all their sides, extending to the outer bark. The accompanying woodcut (fig. 5) will give a much better idea of its structure than our laboured description.

"This specimen clearly proves, by the evidence of internal structure alone, that *Stigmaria* is the root of *Sigillaria*, each of them having an inner radiating cylinder composed of barred vessels, a space occupied by lax cellular tissue, and an outer radiating cylinder composed of tubes or elongated utricles.

27. Carruthers (*Sigillaria, &c.*, 1866).—For the views of this author see page 65 of this Monograph.

28. Schimper (*Sigillaria*).—Professor Schimper[1] classes *Sigillaria* under the *Lycopodinées*, and in the family *Sigillariæ*. He writes—"Trunci cylindrici, simplices vel apice pluries furcati, longitudinaliter sulcati vel læves, foliorum cicatricibus regularibus spiraliter dispositis ornati, cylindro axili continuo vel radiis medullaribus (fasciculis vascularibus?) pertuso medullam crassum includente instructi, cæterum e parenchymate (vivo succulento) cortice solido tecto compositi. Radices crassæ, pluries dichotomæ, longissimæ, horizontaliter expansæ, radiculis longis, simplicibus, crassiusculis, spiraliter dispositis, articulatione circulari insertis. Folia graminiformia triplicata nervo simplici percursa, post lapsum cicatrices relinquentia ovatas, ovato-hexagonas, exacte hexagonas, vel transverse rhombeas, vasorum cicatriculis tribus notatas, medio punctiformi, duabus lateralibus semilunaribus; cicatriculis trunci decortati binis, approximatis hic illic in unam confluentibus, ovalibusve linearibus. Fructificatio spicæformis, sporangiis bractearum basi dilatata insertis.

"D'accord avec la plupart des auteurs modernes, je range les Sigillariées dans l'ordre des Lycopodiacées, malgré la présence des rayons médullaires dans le cylindre ligneux, dont, d'après M. Brongniart, les 'vaisseaux rayés et réticulés' seraient 'disposés en séries rayonnantes' comme dans les Cycadées, ce qui a engagé ce savant à réunir ces plantes aux Gymnospermes. La nature des vaisseaux, en grande partie scalariformes, le vaste parenchyme qui recouvre le cylindre ligneux, la forme régulière des cicatrices foliaires et celles des feuilles elles-mêmes, enfin la mode de fructification, qui est celle des Lycopodiacées, sont des caractères qui rapprochent ces singuliers fossiles plutôt des Lépidodendrées que de tout autre type végétal. D'après plusieurs observations récentes, la végétation souterraine des *Lépidodendron* aurait même une grande ressemblance avec celle des *Sigillaria*. Cette végétation était formée par des racines puissantes, ramifiées par dichotomie répétée, s'étendant horizontalement à de grandes distances et garnies de

[1] 'Traité de Paléontologie Végétale,' tome ii, première partie, p. 76, 1870.

radicelles épaisses, charnues, disposées en spirale, et se désarticulant, comme les feuilles, en laissant des cicatrices persistantes circulaires. Les Sigillariées comptent parmi les plantes les plus communes dans le terrain houiller, et paraissent avoir habité de préférence les endroits marécageux.

"A. *Trunci, Sigillaria,* Brong., *Syringodendron,* Sternb., Brongt., ex. p. Atlas, pl. lxvii, lxviii.

"Trunci arborei, elati, crassi, simplices rarius, ad apicem dichotomi. Foliorum cicatrices, rectiseriatæ, seriebus sulco a se invicem separatis, vel contiguæ corticemque clathrato-reticulatum reddentes, vel tandem distantes atque cortici lævi vel leniter ruguloso insidentes, nunc ovales apiceque truncatæ vel emarginatæ, nunc ovato seu regulariter hexagonæ, rarius transverse rhombeæ diagonali transversa longiore quam recta; cicatriculis fasciculorum vascularium tribus, medio punctiformi, lataralibus lunularibus. Folia ipsa linearia, longa, subplana, vel triplicata, plicis carinatis, spiraliter vel verticillatim disposita.

"Les troncs des *Sigillaria* peuvent être divisés en deux groupes, en troncs cannelés et en troncs lisses. Les premiers sont parcourus de côtes aplaties verticales parallèles, dont chacune porte une seule série de cicatrices; ces côtes ont leurs côtés exactement parallèles, ou elles sont plus ou moins distinctement étranglées entre les cicatrices. Dans les formes où ces côtes n'existent pas les cicatrices sont contiguës, et recouvrent toute la surface du tronc, ou elles sont séparées par des espaces lisses plus ou moins large. Après la chute de l'écorce il ne reste plus sur le tronc que les cicatricules des faisceaux vasculaires, très-variables quant à leur grandeur, ovalaires, réunies ensemble ou confondues en une seule, saillantes ou enfoncées dans une fossette (pl. 67, f. 8, 9, pl. 58). L'arrangement phyllotaxique des cicatrices est analogue à celui des *Lepidodendron.*[1] On remarque assez souvent, entre les séries des cicatrices foliaires, des séries interrompues de cicatrices tout-à-fait différentes de ces dernières. Ces cicatrices sont ovalaires, convexes, ombiliquées au centre, d'où partent en rayonnant plusieurs rides (voy. pl. 67, f. 2 *a*). Ce sont probablement les cicatrices d'insertion des épis fertiles (figs. 12, 13, 14). Sur une espèce, le *Sig. spinulosa,* espèce, dont les cicatrices foliaires sont espacées, et l'écorce lisse, il existe immédiatement sous ces dernières une ou deux petites cicatrices circulaires à bord relevé en bourrelet et ombiliquées au centre. Ces cicatrices ont été prises pour des cicatrices provenant d'épines dont cette espèce aurait été munie, à l'instar de quelques Euphorbiacées frutescentes ou arborescentes. J'y vois des cicatrices de racines adventives. Leur forme est en petit celle de cicatrices des *Stigmaria* (voy. figs. 12, 12 *b*).

"Comme dans les *Lepidodendron,* la structure microscopique du tronc n'a encore été reconnue que sur un très-petit nombre de fragments silicifiés. Je n'ai jamais eu occasion d'examiner de pareils fragments en détail, et me vois, par conséquent, obligé de m'en rapporter à ce qui a été publié sur ce sujet. M. Brongniart, qui a été assez heureux de

[1] Voyez, pour la disposition des feuilles dans les *Sigillaria,* Naumann, 'Ueber d. Quincunx als Gesetz der Blattstellung vieler Pflanzen,' Leipzig, 1845. Goldenberg, 'Flora Sarœp. Foss.,' livre 2, p. 1, et suiv.

pouvoir étudier un échantillon silicifié du *Sigillaria elegans*,[1] dit dans son 'Tableau des genres de végétaux fossiles,' p. 55—'Le caractère essentiel de ces plantes c'est de présenter, dans l'intérieur de leur tige, un cylindre ligneux entièrement composé de vaisseaux rayés ou réticulés, disposés en séries rayonnantes, séparés en général par des rayons médullaires ou par les faisceaux vasculaires qui, de l'étui médullaire, se portent vers les feuilles. Cette organisation est presque identique avec celle des Cycadées; mais outre la différence des formes extérieures, les principaux genres de cette famille, ceux qui appartiennent sans aucun doute à de vraies tiges, présentent, en dedans du cylindre ligneux dont je viens de parler, un cylindre intérieur, sorte d'étui médullaire, continu et sans rayons médullaires dans le *Diploxylon,* divisé en faisceaux correspondant aux faisceaux principaux du cylindre ligneux dans le *Sigillaria.*' Je ne pense pas qu'on puisse prendre les lames parenchymateuses qui séparent les faisceaux vasculaires dont se compose le cylindre ligneux pour des rayons médullaires dans le sens propre du mot. Nous voyons aussi dans d'autres Lycopodiacées les faisceaux vasculaires qui concourent à la formation du cylindre ligneux séparés les uns des autres par un tissu parenchymateux qui se confond avec le tissu médullaire central. M. Binney[2] décrit et figure le cylindre ligneux intérieur de son *Sigillaria vascularis* comme entièrement occupé par un tissu composé de larges vaisseaux scalariformes et d'autres de moindres dimensions (vaisseaux spirals). Le même auteur dit que les rayons médullaires qui passent entre les faisceaux vasculaires dont se compose le cylindre ligneux extérieur sont formés par des vaisseaux finement rayés et se rendent dans les feuilles! Nous aurions donc affaire plutôt à des faisceaux vasculaires partant de l'intérieur du cylindre ligneux que des rayons médullaires. Cela paraît être mis hors de doute par la figure qu'a publiée M. Binney ('Phil. Transact.,' *l. c.*, p. 594) d'un fragment de jeune tige de *S. vascularis,* dans lequel ces soi-disant rayons médullaires sont régulièrement disposés en quinconces. Le cylindre ligneux extérieur est suivi d'un large parenchyme à cellules très-délicates, auquel succède un tissu cellulaire plus lâche, limité extérieurement par le tissu cortical, très-serré, et solide.

"Dans le *S. elegans,* Brong., le cylindre ligneux est formé en partie vers sa partie intérieure de vaisseaux spirals très-étroits; ce même genre de vaisseaux se trouve aussi dans le cylindre médullaire (*voy.* Brong., *l. c.*, pl. xxviii, f. 1 *b*, *b*, B).

"J'ai déjà fait remarquer plus haut que les cicatrices foliaires du *Sigillaria vascularis,* Binney, ne diffèrent pas de celles du *Lepidodendron vasculaire* du même auteur; j'ajouterai

[1] Brongniart, "Observations sur la Structure Intérieure du *Sigillaria elegans,*" &c., 'Arch. d. Mus. d'Hist. Nat.,' tome i, p. 406, pl. xxv–xxviii.

[2] E. W. Binney, "On some Fossil Plants showing Structure, *Sigillaria* and *Lepidodendron,*" 'Quart. Journ. of the Geol. Soc.,' May, 1862, p. 106, pl. iv, v; *idem,* 'Philosoph. Transact.,' mdccclxv, p. 580, pl. xxxi–xxxv. M. Binney figure à la pl. xxxv, f. 6, un échantillon qu'il rapporte au *S. vascularis,* et dont les cicatrices foliaires dénotent évidemment un *Lepidodendron* très-voisin du *L. Veltheimianum,* et probablement identique avec son *S. vasculare.* Voyez aussi, Dawson, "On Vegetable Structure of Coal," 'Quart. Journ. of the Geol. Soc.,' vol. xv, p. 636; *idem,* "Coal. Format. of N. Scotia and New Brunswick," 'Quart. Journ. Geo. Soc.,' xxi, 1865.

encore que la surface extérieure du tronc muni de ces cicatrices, que M. Binney a figuré à la pl. xxxv, f. 6, de son 'Descript. of some Fossil Plants showing Structure' ('Philos. Trans.,' vol. mdccclxv), ressemble à un tel point à celle du *Sagenaria fusiformis*, Corda, ('Beitr.,' tab. vi), qu'il est impossible de l'en distinguer. Ce *Sagenaria* est très-voisin du type de *Lepidodendron* représenté par le *L. Veltheimianum*, type qui pourrait bien former le passage de ce genre au genre *Sigillaria.*

"De nombreuses observations paraissent prouver à l'évidence que le *Lepid. Veltheimianum* possédait pour racine ou rhizome un *Stigmaria;* nous aurions là une nouvelle preuve pour ce passage.

"Il résulte de tout ce que nous venons de dire que, malgré les beaux travaux qui ont été faits sur ce sujet, notre connaissance sur la structure microscopique des tiges de *Sigillaria* laisse encore beaucoup à désirer. Mais je crois que M. Binney a parfaitement raison quand il dit, 'Everything has led me to believe that the leaves and branches (?), and probably the fructification of *Sigillaria* would prove to be very analogous to those of *Lepidodendron*[1] (*loc. cit.*, p. 591).'

"Les *Sigillaria* n'ont jamais été rencontrés en dehors du terrain houiller, et ils abondent surtout dans les formations houillères moyennes et supérieures, dans lesquelles on a souvent observé des troncs d'une hauteur considérable, occupant encore leur position verticale primitive, mais ne montrant jamais aucune ramification. C'est ainsi qu'on a découvert, en construisant le chemin-de-fer de Saarbrücken à Neunkirchen, toute une forêt de Sigillaires encore debout. Dawson a vu la même chose dans les houillères de la Nouvelle Écosse. À Saint-Étienne et à Anzice, en France, les troncs de Sigillaires traversant perpendiculairement plusieurs couches houillères ne sont pas rares. En Europe, comme en Amérique, ce sont surtout les troncs des *S. reniformis* et *lævigata* qui ont conservé ainsi leur position primitive."

29. Williamson (*Stigmaria*, 1871).—See page 71 of this Monograph.

30. Williamson (*Diploxylon*).—After adopting Mr. Carruther's views as to some of the specimens of my *Stigmaria vascularis* belonging to *Lepidodendra*, Professor Williamson[2] treats of *Diploxylon.* He states, "My specimens throw no direct light upon the structure of the vascular and medullary axis of the true *Sigillariæ* as distinguished from the Favularian type; but the cortical portions of all the plants, including the true *Sigillariæ*, exhibit what is practically an identity of structure. In all we have a remarkably thick, spongy bark, reminding us, in many of its features, of that found in the living Cycads. This consisted either of parenchyma, prosenchyma, or of both combined, enclosed externally in a vast layer of elongated prosenchymatous tubes, which, in turn, is invested by a layer of cellular parenchyma supporting the bases of leaves, the latter invariably consisting of the same form of parenchyma as the epidermis. M. Brongniart's specimen of *Sigillaria* (*Favularia*) *elegans* exhibits a central axis the structure of which is nearly iden-

[1] As to *Knorria* having Stigmaroid roots, see p. 89 of this Monograph.—E. W. B.

[2] 'Philosophical Transactions' for 1872, p. 198, and p. 227.

tical with that of my specimen (pl. xxviii, figs. 33 and 34). This, in its turn, only differs from the more ordinary forms of *Diploxylon* in the crenulated outline which separates the ligneous zone from the cylinder of medullary vessels, giving to the exterior of the latter a fluted aspect, like that of a Calamite, but without the transverse nodal constriction of the latter genus. The Diploxylons, again, as I have already shown, shade off into the ordinary forms of *Lepidodendron,* and are, undoubtedly, Lepidodendroid plants which have lost the central portion of their medullary axis. Remove the cellular tissues from the centre of the plant which I have represented in figs. 8 and 9, and we have at once the closest resemblance to Witham's *Anabathra* and Corda's *Diploxylon*, as well as to those now under consideration. That Witham's plant is identical in type with mine is further indicated by his tab. 8, fig. 12, where he exhibits one of the large compound medullary rays shown in my pl. xxvii, fig. 23. The cellular tissues have not been preserved in the medullary rays of Brongniart's *Sigillaria elegans;* but tab. 4, fig. 2, of his memoir shows that his plant possessed similar ones to those which Witham and I have figured. Further, the description which M. Brongniart has given of the *outer* bark and epidermis of his plant, these being the only cortical elements remaining in his specimen, would apply, with little or no alteration, to several of my Lepidodendroid and Sigillarian types; so that, whilst a really indisputable *Sigillaria,* like my pl. xxix, fig. 39, but in which the woody axis is preserved *in situ,* is still an important desideratum, I have very little doubt that, when discovered, it will be found to correspond with one of the several varieties of *Diploxylon.* Most probably, also, my pl. xxv, fig. 8, representing one of the extremes of the two types figured by Mr. Binney under the name of *Sigillaria vascularis,* will also be found to belong to the same subtype of the same genus. Yet my indefatigable friend informs me that his cabinet contains specimens in which the most gradual transition can be traced, from the plant just referred to, to the *Lepidodendron selaginoides,* the oppositely divergent form of the same group, hence his inclusion of both under one common name.

. . . . "Having thus obtained (Williamson, *op. cit.,* p. 238) additional light respecting the Diploxylons, I again turned to the more highly organised of the stems described by Mr. Binney under the name of *Sigillaria vascularis*, and which I have already represented in pl. xxv, figs. 8—11. I made a fresh series of carefully prepared dissections, and succeeded in demonstrating the existence, in this plant, of a series of primary and secondary medullary rays, the former containing large foliar bundles precisely identical with those of *Diploxylon cycadoideum.* I have not succeeded in discovering in the former plant the cellular layer intervening between the medullary vascular cylinder and the woody zone of the latter one. The large primary medullary rays are composed of barred cells, which are sometimes mural, but more frequently prosenchymatous; through the upper part of each of these large rays there proceeds a bundle of true barred vessels. I have not succeeded in tracing one of these bundles to its medullary extremity, consequently I cannot yet affirm how it originates; but I have seen

sufficient to confirm what I have already stated in the body of the memoir, that we need only remove the central cellular medulla of the plant in question to convert it into a true *Diploxylon ;* the identity of the two, so far as structural type is concerned, is as close as it can be even in its minuter details. Such being my conviction, I propose to designate the plant represented in figs. 8—11 *Diploxylon vasculare*, and to apply Corda's name of *D. cycadoideum* to figs. 21—23.

"The plant represented by figs. 33, 34 distinguished by its large medullary axis and by the deeply fluted aspect of the interior surface of its ligneous zone, I propose to designate *Diploxylon cylindricum*; whilst a fourth form, exhibiting some different features yet to be noticed, I would term *D. stigmarioideum*. So far as the general structure of the stem is concerned, the last-named plant does not differ from the other Diploxylons. The cellular medulla has disappeared, but there remains the medullary ring of barred vessels, surrounded by the exogenous ligneous zone. The primary and secondary medullary rays also appear, but neither of them occurs so abundantly as in the other species. Moreover, in the radial vertical sections, the vascular bundles occupying the primary rays exhibit a different aspect from those of the other species described, and approach nearer to what exists in *Stigmaria ficoides*. This is represented in fig. 23, *b*. The vascular bundle (*m*) appears to be derived from the body of the ligneous zone, and not from its medullary surface. It is composed of smaller vessels than those seen at *e* ; but we find that at *e′* these vessels diminish in size, and approach in magnitude those of the bundle *m*; not only so, but, whilst the upper extremities of the small vessels of *m* exhibit the perpendicular arrangement indicating that they belong to the part of the woody zone in which they occur, the lower extremities of the large vessels (*e*) are deflected in the direction of those of the foliar bundle, which is never the case with the corresponding ones of the other forms of Diploxylons. The lower margin of the foliar bundle is cut off in this section by an oblique, sharply defined line; this indicates that the large vessels at *e″* have been sharply deflected to the right and left of the bundle, to allow the latter to pass between them. All these appearances correspond so closely with what we find in *Stigmaria* that for a long time this plant seriously perplexed me; but it appears to be a true *Diploxylon*, since it has the vascular medullary cylinder of that genus as well defined as in any other species. This cylinder is never found in *Stigmaria ficoides*. It has been more especially in connection with this species of *Diploxylon*, though not exclusively, that I have found the peculiar bark represented in figs. 54—57. It is possible that this plant may, like *Stigmaria*, prove to be the uppermost part of a root of some of the other forms, though I have never yet found it associated with any rootlets; or it may be a fragment from the base where stem and roots united.

"Amongst the numerous other interesting plants for which I am indebted to G. Grieve, Esq., of Burntisland, in Fifeshire, is a well-marked *Diyloxylon*, closely allied to *D. cycadeoideum*. Like the rest of Mr. Grieve's specimens, it is from the deposit of the Lower Carboniferous age which occurs embedded amongst trappean rocks at Pettycur Bay.

This specimen is instructive, since, though abundantly furnished with primary and secondary medullary rays, or rather with the spaces which they occupied, all the cellular tissues have disappeared from both, whilst the vascular foliar bundles are well preserved. We are thus enabled to distinguish the respective areas occupied by the two tissues in a manner that I have not succeeded in doing so distinctly in the other specimens described. Each bundle is cylindrical, occupying the centre of the lenticular section of the ray, when cut at right angles to its direction, and consisting of very small, barred vessels. Above and below the vessels are open spaces; but these were originally occupied by the cellular tissues of the ray, the forms of the cells being strongly impresssed upon the indented walls of the contiguous longitudinal vessels of the ligneous zone. I have not discovered in this plant the cellular layer intervening between the medullary vascular cylinder and the woody zone; in this respect it appears to approach nearer to *D. vasculare* than to the other forms. The vascular medullary cylinder or sheath is strangely marked; but all the medullary cellular tissues have disappeared. I pointed out some time ago[1] that some of these *Lepidodendra* exhibited a feature not previously noticed; namely, the vessels were not only barred transversely, but, in addition, the transverse bars of lignine were connected by a delicate series of threads of the same material, running parallel with the longer axis of the vessel. I find this feature in all Diploxylons; but in the Burntisland specimen it is so faint that it can only be discovered under the microscope by a careful adjustment of the light. The coarser transverse bars are also much more irregular in size, number, and direction than is usual amongst the Diploxylons of the Upper Coal-measures.

"The *Diploxylon* of Corda is so obviously identical generically with the *Anabathra* of Witham that the latter name ought to be adopted in preference to the former one. But ere long, in all probability, both these names will have to be abandoned, since there appears little doubt that they represent the woody axes of some of the common Lepidodendroid plants of the Coal-measures; and, as soon as the identification of these internal axes with their correlate external forms is indisputably accomplished, the yet older names of the latter must become the adopted ones. Under these circumstances it is scarcely desirable to disturb a widely accepted nomenclature, since any day may furnish the required connecting link.

"The general conclusion towards which all these additional observations point is the same as that of the preceding memoir, which they strengthen and confirm, viz. that all these varied plants are constructed upon a common type, and belong to one Lycopodiaceous family."

31. NEWBERRY[2] (*Sigillaria*):—"Fossil-botanists have discussed the relations of *Sigillaria* at considerable length, without reaching any universally accepted conclusion. Professor Dawson considers they are Gymnosperms, while Mr. Carruthers regards them as distinctly Cryptogamous, and more nearly allied to Lycopods than to the Conifers. My

[1] 'Monthly Microscopical Journal,' August 1st, 1869, pl. xx, fig. 10.

[2] "Report of the Geological Survey of Ohio," vol. i, Part II, 'Palæontology,' p. B, 65, 1873.

own observations confirm those of Professor Dawson in regard to the structure of the trunk of *Sigillaria.* The outside was evidently composed of a thick cortical integument, to which the leaves were attached. Within this was a mass of cellular tissue, surrounded by a slender woody axis, with a relatively large medullary cavity. This is very unlike the structure of the trunk in most of our Conifers, but it is not very dissimilar to the trunk of Cycads. The probabilities are, that the *Sigillariæ* formed a group of plants considerably unlike any now living, and, as such, served to connect the Gymnosperms with the Acrogens. If this was their botanical position, it would not be at all surprising if we found that they possessed a trunk sharing the peculiarities of the Sago-palms and Tree-ferns, bearing drupaceous fruits not unlike those of the Cycads and some of the infinitely varied Coniferæ. If we compare the fruits of *Pinus*, *Taxus*, *Salisburia*, and *Ephodia*, among the *Coniferæ*, we shall discover such a latitude of structure as will prepare us to accept the association of the fruit of *Trigonocarpon* with the trunk of *Sigillaria* without much hesitation."

32. Renault and Grand' Eury[1] (*Sigillaria spinulosa*) :—" Des faits qui précèdent il résulte principalement que les vraies Sigillaires, ainsi que le pensait déjà M. Brongniart, ont les éléments ligneux arrangés en séries radiales et croisantes, séparés par de vrais rayons médullaires, comme les plantes phanérogames gymnospermes ; que les faisceaux foliaires tirent leur origine de l'étui médullaire, comme il arrive chez les plantes dicotylédones. Entre le cylindre ligneux et l'étui médullaire il n'existe aucune couche cellulaire analogue à celle du *Diploxylon cycadeoidum* signalée par M. Williamson. Les cellules des rayons médullaires ne sont pas barrées comme celles qui forment les rayons médullaires du *Diploxylon* et du *S. vascularis.* Les faisceaux foliaires partent de la portion intérieure et médiane des faisceaux médullaires, celle qui est composée de vaisseaux plus petits, barrés et spirals, et, après avoir traversé le bois obliquement, ils s'élèvent verticalement dans la zone parenchymateuse de l'écorce, et s'infléchissent ensuite pour parcourir presque horizontalement la partie tubéreuse. De chaque côté du faisceau foliaire deux lacunes, parcourues par des canaux volumineux, prennent leur origine dans le tissu cellulaire sous-cortical, et viennent former à l'extérieur, sur la cicatrice, ces deux arcs placés de chaque côté du faisceau foliaire, médian et unique, et si apparents dans les Sigillaires. L'écorce tubéreuse est parcourue obliquement, de bas en haut, par de nombreux rayons cellulaires, limités par un tissu formé de cellules extrêmement régulières, disposées par bandes rayonnantes. Par les caractères les plus essentiels, les *Sigillaires* ont donc bien l'organisation des tiges dicotylédonées, et particulièrement des Gymnospermes et surtout des Cycadées.

" Dans le mémoire cité plus haut M. Williamson, après avoir fait ressortir les analogies existant entre quelques portions de Lépidodendrées, le *Sigillaria vascularis*, les *Diploxylon* et les vraies *Sigillaires*, dont il ne met pas en doute les caractères phanéro-

[1] 'Mémoires à l'Académie des Sciences, &c.,' vol. xxii, No. 9, p. 16, 1874.

gamiques, qui vont, au contraire, comme il le fait marquer, en s'accusant de plus en plus dans ces dernières, conclut que toutes ces variétés de plantes ont le même prototype, et qu'elles appartiennent à une même famille, les Lycopodiacées.

"Tout en reconnaissant ce qu'il y a de séduisant à admettre l'existence d'une longue série de plantes cryptogamiques de plus en plus élevées en organisation, et dont l'un des termes les plus parfaits serait les vraies Sigillaires, qui offrent dans leur structure les principaux traits des Phanérogames—tout en admettant l'importance philosophique d'une hypothèse qui n'a rien que de très-naturel et de très-conforme à ce qui existe dans d'autres branches de l'histoire des êtres—nous pensons devoir rester dans une sage réserve, en attendant le moment, peut-être prochain, où des fructifications parfaitement authentiques et bien conservées permettront de trancher définitivement la question."

33. Brongniart.[1]—In writing on *Trigonocarpon* M. Brongniart states in a note—"Je dois rappeler ici que j'ai toujours considéré, d'après la structure de leurs tiges, les *Sigillaria* et les *Calamodendron* comme se reportant à des types détruits de végétaux arborescents de la grande division des Dicotylédones Gymnospermes, contrairement à l'opinion de plusieurs paléontologistes, qui les rangent parmi les Cryptogames, près des Lycopodiacées et des Equisétacées.

"Le nombre et la variété des graines de Gymnospermes que je signale dans ce memoire confirment cette opinion, que je vois avec satisfaction adoptée par M. Newberry dans son mémoire récent sur diverses graines des terrains houillers de l'État de l'Ohio."

IV. Description of the Specimens.

§ 1. Specimens Nos. 39 and 40, *Sigillaria vascularis*, Binney. Pl. XIX, figs. 1 and 2; Pl. XX, figs. 1, 2, 3, 4, and 5.

The first specimen intended to be described in this Memoir is from a calcareous nodule found in the Halifax "Hard Seam" of coal at South Owram, Yorkshire, and marked "**" in the section of strata given at page 12. It was associated with *Sigillaria*, *Stigmaria*, *Lepidodendron*, *Calamodendron*, and other Coal-measure Plants. The chemical composition of the nodule of limestone and the circumstances connected with the occurrence of the fossil wood are the same as those previously described with regard to No. 3 specimen in this Monograph. The specimen illustrated in Plate XIX, figs. 1 and 2, No. 39, natural size, is of an irregular oval shape, one foot in circumference, five inches in its major and three inches in its minor diameter. When first discovered it was six inches in length, being a fragment of a much larger stem. The light-coloured disk in the middle, about an inch in diameter, shows the central axis and the internal

[1] 'Extrait des Annales des Sciences Naturelles,' "Botanique," 5e série, vol. xx, p. 5, 1875.

radiating cylinder of woody tissue; while lines radiating towards the circumference indicate the outer radiating cylinder composing the inner bark, formed of thick-walled utricles, or elongated cells, of a quadrangular form, arranged in wedge-shaped masses, divided by very coarse cellular tissue, oblong in its transverse section, somewhat like that described by me as occurring in *Calamodendron commune,* and containing a vascular bundle, also wedge-shaped, but increasing in the direction opposite to that in which the first-named wedge-shaped masses do: all figured of the natural size. The outer bark had been converted into a mass of bright coal, about an inch in thickness. Fig. 2 shows the outside appearance of the fossil in a decorticated state, marked with fine longitudinal striæ, irregular ribs and furrows, and some rather indistinct traces of the cicatrices of leaf-scars, which would induce many collectors of coal-plants to class it with a decorticated specimen of *Sigillaria.* The outer bark of the specimen remains attached to it, in the form of coal, united to the matrix of the fossil. The reverse side of the specimen has the same characters, with the exception of the oval protuberance shown in the plate.

In Plate XX, fig. 1, is represented a transverse section of the light-coloured disk previously alluded to and shown, of natural size, in Plate XIX, fig. 1, but here magnified $4\frac{1}{2}$ diameters, exhibiting the central axis composed of hexagonal tubes arranged without order, and of several sizes, those in the middle being rather smaller, but becoming larger towards the outside, where they come in contact with the internal radiating cylinder *b*, and then again diminishing in size just at the point of junction. This was no doubt originally cylindrical, like the stem of the plant; but both parts, in the process of petrification, have been altered by pressure to their present forms. It consists of a broad cylinder (*b*), about an inch in diameter, composed of parallel, elongated, tetragonal, or hexagonal tubes, of equal diameter throughout for the greater part of their length, obtuse or rounded at either extremity, and everywhere marked with crowded parallel lines, which are free or anastomosing all over the surface. The tubes towards the axis are of the smallest diameter; they gradually enlarge towards the circumference, where they are the largest, though bundles of small tubes occasionally occur among the larger. This cylinder, which may be called the internal woody system of the plant, is divided into elongated, wedge-shaped masses, pointed at their posterior or inner extremities, and parted by vascular bundles and fine medullary rays, of various breadths, some much narrower than the diameter of the tubes, others considerably broader, but none are conspicuous to the naked eye, except towards the circumference in some few instances. The disarrangement of the tubes of the central axis seems to be the result of the process of mineralization, as similar appearances have not been observed in many other specimens examined, which in that part are in a more perfect state of preservation. The dark and sharp line separating the vessels of the central axis from those of the internal radiating cylinder does not permit us to clearly see the origin of the vascular bundles or medullary rays which undoubtedly traverse the latter.

Fig. 2 represents a longitudinal section through the specimen, extending across the

whole of the internal radiating cylinder and the central axis, magnified 12 diameters; (*a*) showing the barred tubes of the central axis; (*b b*) the internal radiating cylinder of barred tubes, at first next the central axis, small, but increasing in size; (*c c*) as they approach the outside. In this section no part of the zone of lax cellular tissue, the outer radiating cylinder, the prosenchymatous tissue forming the inner bark, or of the outer bark, is shown; nor are there any traces of vascular bundles.

Fig. 3 is a tangential section of a portion of the inner radiating cylinder, magnified 16 diameters; (*d*) showing the large bundle of vascular tubes, and (*d'*) the medullary rays consisting of a single row of cells traversing the inner radiating cylinder.

Although all the tangential sections afford evidence of these two kinds of rays, they have not been yet observed in the longitudinal sections; so we cannot be certain whether the larger have a bundle of vascular tissue surrounded by cellular tissue, like those seen in *Stigmaria*, or not; and we have no direct evidence to connect them with the pith or central axis, the latter being separated from the inner radiating cylinder by a sharp and distinct line, and showing no communication with the pith, such as is seen in some *Stigmariæ*, and in Corda's *Diploxylon cycadoideum;* but exactly resembling Witham's *Anabathra pulcherrima* in every particular.

Fig. 4 is a portion of the outer radiating cylinder, composed of small rectangular tubes, or elongated utricles, magnified 12 diameters. This band of prosenchymatous tissue is traversed by wedge-shaped masses of lax cellular tissue, which gradually diminish in size as they approach the outer bark. The tangential section does not exhibit the vascular or foliar bundles in so good a state of preservation as my large specimen in plate xxxiv, vol. clv, of the 'Phil. Trans.,' but it shows that they are exactly of the same character, so far as they have been preserved.

Fig. 5 (No. 40). This is a transverse section of the inner radiating cylinder, enclosing a central axis or pith, of a small *Sigillaria vascularis*, in all respects, except as to size, similar to the large specimen; magnified 9 diameters. The tubes in the centre, both great and small, are barred on their sides. The specimen has an outer zone of lax cellular tissue, passing into the outer radiating cylinder of prosenchymatous tissue, surrounded by an epidermis converted into coal. The figure is given for the purpose of showing that the small specimens of *Sigillaria vascularis*, with piths of barred vessels, first described by me in the 'Quarterly Journal of the Geological Society,' pass gradually into the large specimens described in the 'Philosophical Transactions' and in the present Monograph.

A number of the central axes have been taken out of the internal radiating cylinders of *Sigillaria vascularis* for the purpose of endeavouring to trace the connection of the medullary rays with the central axes or piths; but no evidence was obtained to show where these rays originated. They could only be traced to the dark line separating the pith from the inner radiating cylinder, but not passing through that line.

The inner walls of the outer radiating cylinder, next the central axis or pith, were

found to be finely ribbed and furrowed longitudinally; but no trace of openings, either large or small, similar to those seen on the inner walls of the open-wedged *Stigmariæ*, was met with. In my Memoir in the 'Philosophical Transactions,' figures of three piths, taken out of three specimens of *Sigillaria vascularis*, are given. They consist of barred tubes, and are all alike in their outward appearance, being slightly ribbed and furrowed; but they present no casts of oval openings, such as are seen on the inner sides of the wedge-shaped bundles of the inner radiating cylinder of *Stigmaria* of the open-wedged character.

This specimen in all respects resembles the large specimens of *S. vascularis* described by me in the 'Phil. Transactions,' but the outer radiating cylinder is not shown so well in tangential section as No. 2 therein mentioned. Still sufficient evidence is afforded of the wedge-shaped masses of large and lax parenchymatous tissue, enveloping a kidney-shaped bundle of barred tubes, which traverse and divide the wedge-shaped masses of prosenchymatous tubes or utricles in their way to the leaves. They are not seen in the transverse and longitudinal, only in the tangential, sections; and have not been found to anastomose, as described by MM. Renault and Grand' Eury in the specimen of *Sigillaria spinulosa* described by them.

§ 2. The Specimens Nos. 41, 42, and 43, *Stigmaria ficoides*. Plate XXI, figs. 1—7.

Specimen No. 41, fig. 1 (magnified 6 diameters), is a transverse section of a *Stigmaria ficoides*, found by me in the "Bullion Seam" (marked ** in the section of strata of the Lancashire Coal-measures hereinbefore given at page 12 of this Monograph) at Clough Head, near Burnley, in a calcareous nodule. The specimen is oval, and about an inch in diameter; but the figure only represents the inner radiating cylinder and one of the vascular bundles proceeding to the rootlets, the medulla being absent. The wedge-shaped masses of the wood are parted by wide spaces, and their ends are slightly convex, projecting into the space formerly occupied by the medullary tissue; in every respect similar to Goeppert's specimen, and quite different from the close-wedged example from North Staffordshire described by me in the 'Quarterly Journal of the Geol. Soc.,' which had its woody system separated from the medulla, or central axis, by a sharp and distinct line. The tubes are quadrangular, and arranged in radiating series, being smallest near the axis, and gradually increasing as they approach the circumference. On the left-hand side of the figure there is represented one of the bell-shaped cavities that contained the vascular bundles communicating with the rootlets; but the zone of lax parenchymatous tissue, surrounding the inner radiating cylinder, as well as the outer radiating cylinder, formed of prosenchymatous tissue, first described by me in my Memoir in the 'Philosophical Transactions,' are not shown.

Fig. 2 (magnified 6 diameters) is a longitudinal section of the same specimen, showing the space formerly occupied by the medulla, but now only containing a little disarranged tissue (*a*), the smaller tubes next the medulla, barred on all their sides, forming the inner radiating cylinder (*c*), traversed by one of the large vascular bundles (*d*), proceeding from the medulla towards the outside and the bell-shaped cavity containing the vascular bundle (*d*), traversing the zone of lax parenchymatous tissue (*e*), is well shown on the left-hand side of the figure.

Fig. 3 (magnified 8 diameters) is a tangential section of the same specimen, showing the large oval vascular bundle (*d*), and the numerous small medullary rays of single cells in vertical series (*d′*) traversing the woody cylinder.

Fig. 4 (natural size) is a representation of the outside of the specimen, showing cicatrices of rootlets.

Specimen No. 42, fig. 5 (natural size), shows a beautiful pyritized specimen of *Stigmaria ficoides*,[1] the common open-wedged form, from the Lower Coal-measures of Lancashire (the exact locality not known), exhibiting the inner radiating cylinder in a perfect condition, with the inner ends of the wedge-shaped masses of the woody cylinder pierced by elongated oval cavities, in which were the large vascular bundles communicating with the central axis and proceeding to the rootlets.

Fig. 7, specimen No. 43 (magnified 6 diameters), represents the inner portion of another pyritized specimen from the "Stinking Two Row Seam" of coal at Golden Hill, North Staffordshire, in which the parts of the wedge-shaped masses of the woody cylinder next the medulla not only show the large oval orifices described in No. 42, but also traces of the small medullary rays seen in the tangential sections of the inner parts. This specimen is close-wedged, and is a portion of that described by me in the 'Quarterly Journal of the Geological Society,' and contains the large tubes in the central axis which some writers have taken to be the rootlets of other *Stigmariæ* that have invaded the medullary portion of the plant.

The oval openings (*d*) seen on the ends of the wedge-shaped masses of the woody cylinder are all arranged in quincuncial order, exactly the same as the rootlets are on the outside of the root, and doubtless contained the vascular bundles which proceeded from the medulla and communicated with the rootlets.

[1] This is part of a specimen which many years ago led me to search all the Lower Coal-measures of Lancashire and Yorkshire for a long time, until I discovered the calcareous nodules in the "Brooksbottom" and "Upper Foot Coals" near Burnley, Oldham, and Halifax, yielding specimens showing structure, about twenty years since.

§ 3. The Specimen No. 44, *Sigillaria vascularis,* Binney. Plate XXII, figs. 1—4, and Plate XXIII, figs. 1—3.

Specimen No. 44, fig. 1 (natural size), is the outside of a calcareous nodule from the "Bullion Seam" of coal at Clough Head, near Burnley, showing the transverse section of a root, in a most beautiful state of preservation. Every part of the central axis (composed of large and small tubes and cells, barred on all their sides, and arranged without order) is entirely preserved in its structure, as is also the woody cylinder surrounding it; about one half of its diameter arranged in radiating series, with no division in its wedges, and separated from the axis by a sharp and distinct line. No oval openings are seen in the thin end of the wedges, like those of the *Stigmaria* (No. 41) hereinbefore described. On the outside of the woody cylinder is a zone of lax parenchymatous tissue, much disarranged, but gradually passing into an outer radiating cylinder of prosenchymatous tissue, which is traversed by numerous bell-shaped cavities, that contain the vascular bundles leading to the rootlets. In fact, we have a *Stigmaria* showing a medulla, or central axis, surrounded by a woody cylinder, but separated from it by a distinct line of demarcation, and having none of the openings communicating with the central axis such as are met with in *Stigmariæ* like No. 41. The scars, in the form of depressed areolæ, on the outside, are not shown, being enveloped in the matrix of carbonate of lime; but the bell-shaped cavities are well exhibited, and sufficient to prove it to be a *Stigmaria,* and in all respects similar in structure to the specimen of *Sigillaria vascularis,* Nos. 39 and 40, hereinbefore described.

Fig. 2 (magnified 6 diameters) is a representation of the central axis and the inner radiating cylinder; the former composed of large and small tubes and cells, barred on all their sides; the latter being found chiefly near the centre, and the outside next to the woody cylinder. The last-named part is composed of rectangular tubes, placed close together, increasing in size as they extend outwards, and in radiating series. This figure is taken by reflected light.

Fig. 3 (magnified 15 diameters) is a transverse section of another portion of the inner radiating cylinder, composed of rectangular tubes, showing a large vascular bundle and a small medullary ray.

Fig. 4 (magnified 12 diameters) is a tangential section of the inner radiating cylinder of barred tubes, showing a large oval vascular bundle of about thirty cells[1] (*d*), and smaller medullary rays of one and two cells each (*d'*), arranged in vertical series.

Plate XXIII, fig. 1 (magnified 8 diameters), is another transverse section of the same specimen, in a different part of the root, and seen by transmitted light, showing the central axis and the inner radiating cylinder, as previously described. It is given for the

[1] In the figure only six cells are shown, but more than thirty are seen by a high power.

purpose of showing that different transverse sections of the root give the same result as to the structure of the central axis.

Fig. 2 (magnified 8 diameters) is a transverse section of a portion of the root taken near the outside of the specimen, showing the lax parenchymatous tissue (*e*) passing into the outer radiating cylinder of prosenchymatous tissue, formed of rectangular tubes (*f*), traversed by four bell-shaped cavities (*d*), connected with the pear-shaped bundle of barred tubes, like those found in *Stigmaria* rootlets. In one of these cavities is a rootlet.

Fig. 3 (magnified 8 diameters) is a longitudinal section (unfortunately not very true, being nearly diagonal across the inner radiating cylinder and the central axis) showing the large and small tubes and cells (*a*) which, by the direction of the section, appear like utricles and cells, large and small, barred on all their sides, the small tubes (*b*) next to the central axis and the larger tubes (*c*), also barred on all their sides, forming the inner radiating cylinder. In this figure the small tubes appear more like cells than tubes; but under a high magnifying power they show the bars on their sides, like those seen on the larger tubes.

In all the longitudinal sections of specimens of *Sigillaria vascularis* (Nos. 39 and 40) we have not been able to trace any vascular bundles proceeding from the central axis or traversing the inner radiating cylinder, having their origin in a medulla or a medullary sheath, similar to those found in the *Stigmaria ficoides* with open wedges. In the tangential section we cross the large vascular bundles and small medullary rays, which in their sectional view do not afford any direct evidence of their being formed of barred tubes, and this is all that can be said of them. In the examination of numerous casts of the outside of the medulla, or central axis, of *Sigillaria vascularis*, as previously stated, there have been found no openings in the ends of the wedge-shaped masses of the wood of the inner radiating cylinder, like those found in the open-wedged *Stigmaria*. This is the case with all the specimens of *Diploxylon cycadoideum* and *Sigillaria vascularis* that have come under my observation. In tangential sections of the outer radiating cylinder or inner bark of the latter plant (pl. xxxiv, fig. 2, in my Memoir in the 'Phil. Trans.') there is evidence of a foliar bundle similar to that shown to exist in *Sigillaria spinulosa* by MM. Renault and Grand' Eury. This is also seen in similar sections of the small *Sigillaria vascularis* described by me (*loc. cit.*, pl. xxxv, fig. 5), and which Professor Williamson and Mr. Carruthers think is a *Lepidodendron*, and which Professor Schimper identifies with *L. Veltheimianum.*

The large size of the tubes and cells in the medulla is very remarkable, and in a great measure accounts for the absence of that part of *Stigmaria;* for such bodies were not likely to have been able to resist decomposition for any considerable time; and it also tends to confirm the probability of the large tubes found in the pith of my Staffordshire specimen, hereinbefore referred to and questioned by Professor Williamson.

§ 4. The Specimen No. 45, *Stigmaria ficoides*. Plate XXIV, figs. 1—3.

Fig. 1 (natural size) represents the exterior of a decorticated *Stigmaria ficoides*, found by me on an old coal-pit hillock at Over Darwen, Lancashire. It is uncertain whether it came from the "Gannister" or from the "Lower Fort Mine" of the Lower Coal-measures, as both those seams had been wrought in the pit. It occurred in a nodule of rich clay-ironstone. The depressed areolæ, with a little mammelon in the centre, marked by a dark spot, as also the corrugated lines surrounding the areolæ, are very distinct, and a better specimen of *Stigmaria ficoides*, of small size, is not often met with, as far as its exterior is concerned.

The rootlet from which my sections were taken was imbedded in the outer radiating cylinder, or inner bark, about half an inch in depth, and was originally one fourth of an inch in diameter, but it had diminished one half, probably from the removal of its thick carbonaceous exterior during the process of petrification. The remaining eighth of an inch is, for the chief part, composed of crystallized matter, most probably silica; and it is only a small circular speck, about one thirtieth of an inch in diameter, in the centre of the rootlet, that affords evidence of structure.

Fig. 2 (magnified 90 diameters) is a transverse section of the small circular speck. Its exterior consists of a ring of fine parenchymatous tissue, three or four cells in breadth. This is surrounded by a space, four or five times the diameter of the ring above named, in which no structure is apparent, the fine tissue formerly occupying it having disappeared; then in the centre there is a beautiful pear-shaped mass of vascular tissue, one ninetieth of an inch in diameter, consisting of twenty-seven large vessels, of hexagonal, pentagonal, and other shapes, and of a bundle of very minute nearly circular vessels at the upper extremity.

Fig. 3 (magnified 90 diameters) is not a straight section, being about half way between a longitudinal and a transverse section; but it clearly proves that the vascular tubes on all their sides were marked with transverse striæ, as described by Professor Goeppert in 1841; but his specimen did not exhibit so many vessels, only eleven, and was not in so good a state of preservation as the one here described. Dr. J. D. Hooker also examined and described a similar specimen, but it was not very distinct. As none of the rootlets thus described were traced to their exact position in the main root; and as in my first description in the 'Quarterly Journal of the Geol. Soc.' no figure was given of the *Stigmaria* in which the rootlet occurred, it has been considered desirable to again describe the specimen and at greater length.

§ 5. The Specimens Nos. 46 and 47, *Stigmaria ficoides.* Plate XXIV, figs. 4, 5, No. 46; figs. 6, 7, 8, No. 47.

Fig. 4 represents, on a greatly reduced scale, the base of a stem (No. 46) having the irregular ribs and furrows so generally found on the outside of *Sigillaria vascularis* when in a decorticated state. The greatest breadth across the specimen is about four feet and six inches, from one of the main roots to the other on the opposite side.

Fig. 5, on a greatly reduced scale, represents the under side of the same specimen, showing the crucial sutures.

Specimen No. 47, fig. 6, on a greatly reduced scale, shows the base of another decorticated stem, having its sides covered with the same kind of irregular ribs and furrows as above described on No. 46. The greatest breadth across the specimen is about thirty inches. As part of the secondary roots of this specimen remain, there is evidence of the same system of dichotomization which has been observed in the Dixon Fold, St. Helens, and other examples of large fossil trees of *Sigillaria vascularis.*

Fig. 7 represents the under view of the same specimen, showing the crucial sutures.

Fig. 8 shows the distinct areolæ, with a little round elevation in the centre, and the convex corrugated lines so commonly found on the outside of *Stigmaria.*

The above specimens are in the Museum of the Leeds Philosophical Society, and were observed in 1839 by the late Mr. Bowman and myself. That gentleman made drawings of them at the time, and the present figures are reduced copies. The specimens consist of a fine-grained sandstone; and we were informed that they had been found in the Lower Coal-measures near Bradford, Yorkshire.

In alluding to these singular sutures Dr. Hooker, at page 417 of his memoir,[1] says—"A yet more remarkable and anomalous structure in *Sigillaria* than either that of their stigmaroid roots or fluted stems was pointed out to me by Mr. Binney. This is the curious crucial mark which quarters the base of the trunk. The *Sigillaria* generally divides into four main roots at the base, which unite to form the crown of the dome described by Lindley and Hutton; and it is along the line of union of these four roots that these strongly marked lines run, all meeting at the centre of the dome. I know nothing analogous to this in recent or fossil botany."

Dr. Schimper observes[2]—"On remarque très-souvent à la face inférieure du tronc une suture en forme de croix, dont les extrémités correspondent aux angles de bifurcation

[1] 'Memoirs of the Geological Survey of Great Britain,' vol. ii, part ii, p. 417.

[2] 'Traité de Paléontologie Végétale,' vol. ii, p. 112.

des quatre racines primaires. Cette suture n'est autre chose qu'une ligne de contact produite par l'epaississement de ces quatre racines (voy. notre pl., fig. 14); elle se continue aussi vers le haut entre ces mêmes racines."

V. Concluding Remarks.

When Brongniart described his *Sigillaria elegans*, the Rev. Mr. Harcourt's *Lepidodendron*, Lindley and Hutton's *Stigmaria*, and Mr. Witham's *Anabathra*, he had before him all the materials then known, for examining the structure of those plants, that the Coal-measures had afforded. Subsequently Corda added the *Diploxylon cycadoideum*. Then Goeppert described his *Stigmaria* with the vascular bundles in the pith. But in all these specimens, except the last, the structure of the piths was more or less wanting. The first time that anything was published as to stems with vascular tubes in their piths was in my paper in the 'Quarterly Journal of the Geological Society,' and this was further extended in my Memoir in the 'Philosophical Transactions,' where were described larger specimens of *Sigillaria vascularis* and *Diploxylon cycadoideum*, all showing structure similar to that of the smaller ones first described, with the exception of the *Diploxylon* having the edges of the woody bundles of the inner radiating cylinder slightly lunette-shaped, and running into the pith, like those described by Corda in his specimen, but in a less degree. Professor King, in his description of Witham's *Anabathra*, shows it to be like *Sigillaria vascularis*, except in the pith, which was not distinctly shown. Each plant had the same medulla, inner radiating cylinder traversed by large and small medullary rays, since termed primary and secondary, the same zone of lax parenchymatous tissue, gradually passing into prosenchyma, and traversed by vascular bundles leading to the leaves, and which, although traced to the outside of the inner radiating cylinder, could not be absolutely proved to be connected with the large medullary rays, and the same outer bark generally converted into bright coal. It was also asserted that the small *Lepidodendroid* stem gradually passed into the irregularly ribbed and furrowed *Sigillaria*, and that the open-wedged *Stigmaria* belonged to *Diploxylon cycadoideum*, as its root, whilst the close-wedged one belonged to *Sigillaria vascularis*. Since these, in this Monograph, Mr. Dawes' specimen of *Lepidodendron Harcourtii* has been described, and shown to contain a medulla of orthosenchymatous tissue, which Mr. Harcourt's specimen did not afford. The question now for consideration is this,—is the latter to be regarded as the type of the structure of *Lepidodendron*, or is the new plant described by me to be so regarded, taking the evidence of internal structure, without regarding the external character. So far as the former goes, it appears to me desirable for the present to limit the genus *Lepidodendron* to the old type; and therefore I object to Mr. Carruthers taking my small specimens as *Lepidodendron*, and Professor Williamson taking my large ones as *Diploxylon vasculare*. My

names are only provisional, but I think it better that they should remain until we know more of the fructification of the plant.

In all the large specimens of *Sigillaria vascularis* hitherto observed the zone of lax parenchyma intervening betwixt the inner and outer radiating cylinders is so disturbed that we have been unable to absolutely prove that the vascular bundles which traverse the one are connected with those that traverse the other, however probable it may appear that such is the case. In the small specimen, where this part of the plant is seen in contact with the inner radiating cylinder, and extending to the leaf-scars, it proceeds in a nearly horizontal direction, as previously shown in the woodcut (fig. 5), very differently to the vascular bundle of the *Lepidodendron Harcourtii* (No. 31) described in this Monograph, which at first proceeds from the medullary sheath in a nearly vertical direction, and then makes a gradual curve to the leaf-scar. It appears to me nearly certain, as some authors have suggested, that the large vascular bundles which traverse the inner radiating cylinder, and proceed through the outer one to the leaves, are really foliar bundles, and not medullary rays, and that we must limit the term "medullary ray" to the single- and double-celled rays found in the tangential sections of the inner radiating cylinder.

In examining the structure of Coal-measure Plants we labour under great difficulties, owing to the fragmentary state of the specimens, and we have to collect evidence gradually and with patience. It has never been my practice to pretend to do much more than to collect the best specimens, and to carefully describe them, in accordance with the advice of that great botanist, the late Dr. Robert Brown, who more than once stated to me that such was the course he should recommend, and which he himself would adopt. To other more experienced botanists is left the task of comparing the ancient with the modern flora.

To those who asserted confidently that *Sigillaria vascularis* had a medulla of parenchyma, and not of barred tubes, specimen No. 39, hereinbefore described, is adduced as evidence in favour of my views and against theirs; and to those who contended that *Stigmaria* had a medulla of parenchyma, and not of barred tubes as alleged by me, the specimen No. 44 is brought forward in support of my view that such root had a medulla of barred tubes and cells. Both these specimens, to my mind, appear to prove that *Sigillaria vascularis* had for its root a *Stigmaria* with a medulla of barred tubes and cells similar to those found in its own stem, whatever kind of *Stigmaria* other *Sigillariæ* had for their roots. But up to this time, with the exception of No. 46, to my knowledge, no specimen has been described and figured in such a perfect state of preservation, as to prove satisfactorily the true nature of the pith of the root. This remains to be done.

For all the numerous species of *Sigillaria*—and their number is very great—little evidence has been obtained to prove the nature of their respective roots, either by similarity of structure or absolute connection.

As to the fructification of *Sigillaria*, it appears to me pretty certain that it will prove to be something like that of *Lepidodendron*, except that the structure of the axis of the cone will show that it was composed of barred tubes and cells similar to those found in *Sigillaria vascularis*, and not of orthosenchymatous tissue, as has been proved to be the case in *Lepidodendron Harcourtii*, the first and only *Lepidodendron* in which the structure of both stem and cone has been well ascertained. The structure of the specimen No. 19, described at page 49 of this Monograph, as well as the cone mentioned and described in my paper in the 'Philosophical Transactions,' seem to indicate this as most probable.

The outside of the last-named cone, which came from the nodules in the *roof* and not in the *seam* of the "Upper Foot Coal" near Oldham, where most of the specimens are found, was not so well illustrated in the woodcut as it might have been. The bracts supporting the sporangia are arranged around the column of the cone in vertical series and quincuncial order, differently from those in *Lepidodendron Harcourtii*, and exactly resembling the arrangement of the leaf-scars in *Sigillaria organum*. In fact, the ribs, furrows, and scars shown on the outside of the column of this cone are in all respects similar to those found on a small stem of *S. organum*.

PLATE XIX.

Sigillaria vascularis, Binney.

Fig. 1 (No. 39). Transverse section of a stem from the "Hard Bed" of Coal at North Owram, Yorkshire, showing the pith, internal radiating cylinder, lax cellular tissue, external radiating cylinder, and outer bark. The wedge-shaped spaces of a light colour indicate the lax cellular tissue enveloping the foliar bundles communicating with the leaves. Natural size.

Fig. 2. External view of the same specimen, partly decorticated, showing the irregular ribs and furrows. Natural size.

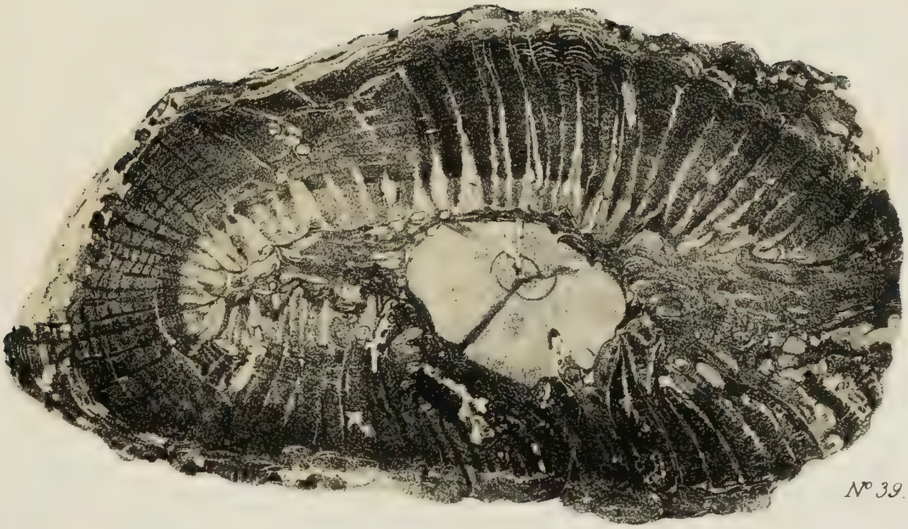


Fig. 1.

Fig 2.

J.N. Fitch, del et lith.

R. Fitch, imp

PLATE XX.

Sigillaria vascularis, Binney.

Fig. 1 (No. 39). Transverse section of the pith and internal radiating cylinder. Magnified $4\frac{1}{2}$ diameters.

Fig. 2. Longitudinal section of the pith, internal radiating cylinder, and a portion of the outside. Magnified 12 diameters.

Fig. 3. Tangential section of a part of the internal radiating cylinder, showing the vascular bundles and medullary rays. Magnified 16 diameters.

Flg. 4. Longitudinal section of a part of the outside radiating cylinder of elongated cells or utricles. Magnified 12 diameters.

Fig. 5 (No. 40). Transverse section of a small specimen from the "Bullion Coal," near Burnley, showing the pith and internal radiating cylinder. Magnified 9 diameters.

In this and the following plates the same parts of the specimens figured are indicated by the same letters, as follow:—

a. The middle part, showing the central axis or pith, composed of large and small scalariform tubes, or utricles and cells, but occasionally more or less separated by fine orthosenchymatous tissue.

b. The small scalariform tubes forming the inner portion of the woody cylinder.

c. The large scalariform tubes forming the outer portion of the woody cylinder.

d. The vascular bundles proceeding from the inner radiating cylinder, traversing the outer radiating cylinder, and extending to the leaves and rootlets.

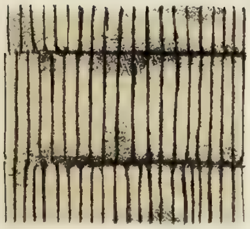
d'. The medullary rays, formed of a single or double row of cells, seen in a tangential section of the woody cylinder.

e. The mass of parenchymatous tissue, at first (near the woody axis) of a coarse and lax character, but becoming finer and denser as it proceeds outwards, until it becomes prosenchymatous.

f. The elongated tubes, or utricles, arranged in radiating series, forming the outer zone next the epidermis.

g. The epidermis of the plant, nearly always converted into coal.

Fig. 4



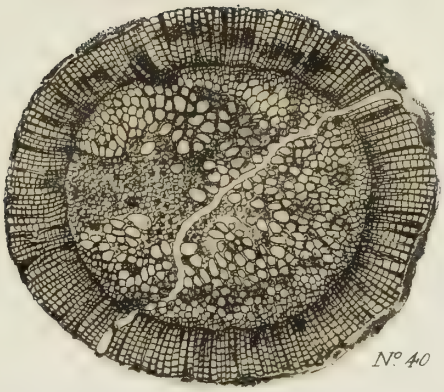


Fig. 5.

Fig. 3

Fig. 1

Fig. 2

J. N. Fitch, del. et lith.

R. Fitch, imp.

PLATE XXI.

Stigmaria ficoides, Lindley and Hutton.

Fig. 1 (No. 41). A transverse section of a specimen from the "Bullion Seam" of Coal, near Burnley. Magnified 6 diameters.

Fig. 2. Longitudinal section of the outer radiating cylinder, and a portion of the outside of the specimen, showing the bell-shaped cavities, from which the rootlets proceed. Magnified 6 diameters.

Fig. 3. A tangential section of the same specimen, showing the vascular bundles and the medullary rays. Magnified 8 diameters.

Fig. 4. The outside of the specimen. Natural size.

Fig. 5 (No. 42). A transverse view of a specimen (locality unknown), showing the wedge-shaped masses of the internal woody cylinder, separated by spaces traversed by the vascular bundles. Natural size.

Fig. 6. A longitudinal view of the narrow ends of the wedge-shaped masses of the woody cylinder next the pith, traversed by vascular bundles. Magnified 4 diameters.

Fig. 7 (No. 43). A longitudinal section of a specimen from Golden Hill, North Staffordshire, showing the narrow ends of the wedges forming the woody cylinder next the pith, and exposing the spaces traversed by the vascular bundles, as well as smaller single-celled orifices, which appear to have been occupied by medullary rays. Magnified 6 diameters.

Plate XXI.

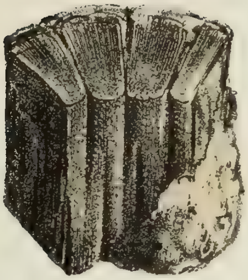


Fig 6

No. 42

Fig 5

No. 43.

Fig. 7

No. 41

Fig 1

Fig 2

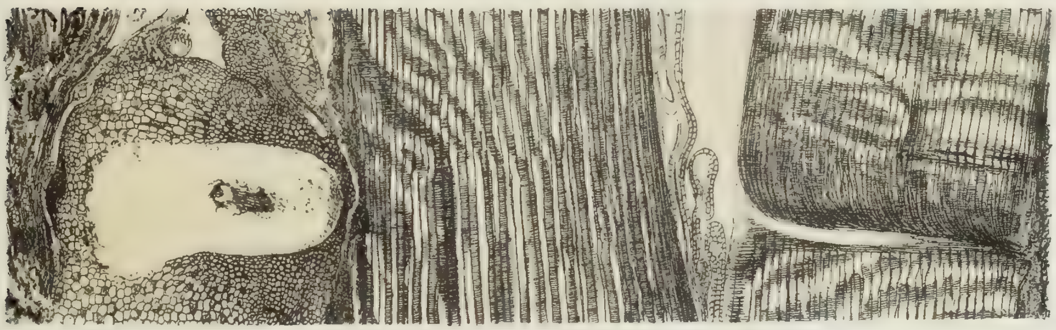
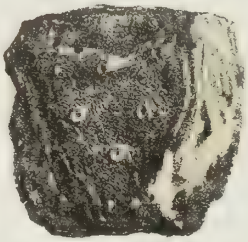


Fig 3

Fig 4



No. 41

J.N. Fitch, del. et lith.

R. Fitch, imp.

PLATE XXII.

Sigillaria vascularis, Binney.

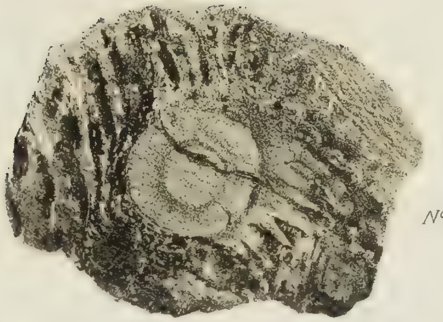
Fig. 1 (No. 44). A transverse section of a specimen from the "Bullion Seam" of Coal, near Burnley, showing the pith, internal radiating cylinder, cellular tissue, and external radiating cylinder with bell-shaped orifices. Natural size.

Fig. 2. Pith and internal radiating cylinder as seen by reflected light. Magnified 6 diameters.

Fig. 3. Transverse section of a part of the outside of the internal radiating cylinder, showing vascular bundles and spaces where medullary rays may have passed. Magnified 15 diameters.

Fig. 4. Tangential section of the internal radiating cylinder, showing a vascular bundle and medullary rays. Magnified 12 diameters.

Plate XXII



N°44

Fig 1

Fig 2

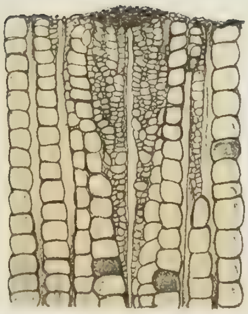


Fig 3

Fig 4

PLATE XXIII.

Sigillaria vascularis, Binney.

Fig. 1. Another transverse section of No. 44, from a different part of the specimen, showing the pith and internal radiating cylinder. Seen by transmitted light. Magnified 8 diameters.

Fig. 2. Transverse section of a portion of the external radiating cylinder, composed of elongated cells (prosenchyma) and parenchymatous tissue, traversed by four bell-shaped orifices, by which the vascular bundles communicated with the rootlets. Magnified 8 diameters.

Fig. 3. Longitudinal section of the pith of small barred cells containing large barred tubes or utricles, and the internal radiating cylinder of barred tubes. Magnified 8 diameters.

Fig 2.

Fig 1

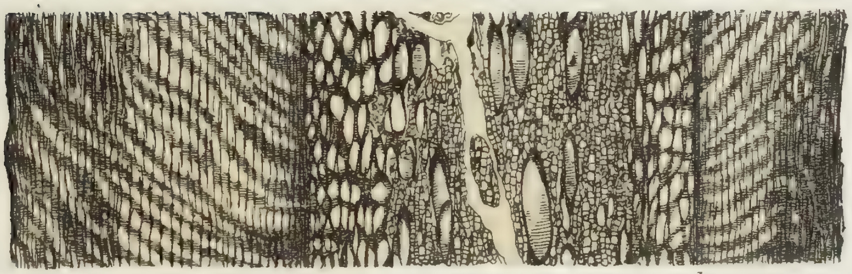


Fig 3

J.N.Fitch del. et lith. R.Fitch, imp

PLATE XXIV.

Stigmaria ficoides, Lindl. and Hutton.

Fig. 1 (No. 45). The exterior of a decorticated specimen, from the Lower Coal-measures of Lower Darwen, Lancashire, showing corrugated lines and depressed areolæ, the latter with a circular central elevation, being the outside of the bell-shaped cavities containing the vascular bundles communicating with the rootlets. Natural size.

Fig. 2. Transverse view of the centre of the rootlet, showing the ring of lax cellular tissue, and the vascular bundle in the middle. Magnified 90 diameters.

Fig. 3. Section, partly transverse and partly longitudinal, showing the ring of cellular tissue and the transversely barred vessels of the vascular bundle in the middle. Magnified 90 diameters.

Fig. 4 (No. 46). Side view of a specimen from the Lower Coal-measures, near Bradford, Yorkshire, showing four main roots. Much reduced.

Fig. 5. Under view of the base of the same specimen, showing the crucial sutures. Much reduced.

Fig. 6 (No. 47). Side view of a specimen from the Lower Coal-measures, near Bradford, showing four main roots. Much reduced.

Fig. 7. Under view of the base of the same specimen, showing the crucial sutures. Much reduced.

Fig. 8. A portion of the exterior of one of the main roots, showing the corrugated lines and depressed areolæ, usually found on the outside of *Stigmaria.* Much reduced.

Plate XXIV.

Fig 4

N° 46.

Fig 2

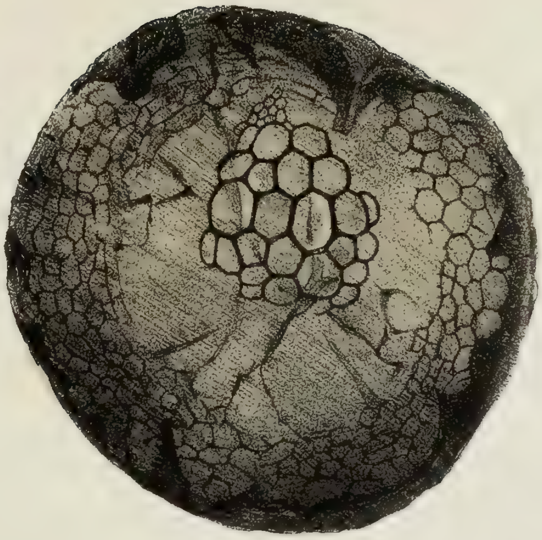
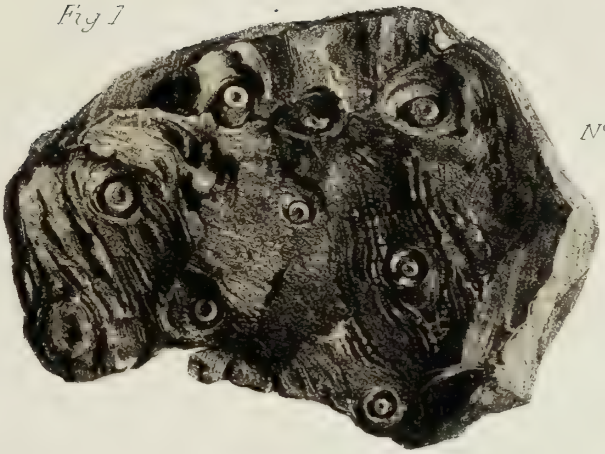


Fig 5

Fig 8

Fig 1



N° 45

Fig 6

N° 47

Fig 3

Fig 7

J. N. Fitch del et lith

R. Fitch, imp

THE

PALÆONTOGRAPHICAL SOCIETY.

INSTITUTED MDCCCXLVII.

VOLUME FOR 1875.

LONDON:

MDCCCLXXV.

MONOGRAPH

ON THE

BRITISH FOSSIL

ECHINODERMATA

FROM

THE CRETACEOUS FORMATIONS.

BY

THOMAS WRIGHT, M.D., F.R.S. EDIN., F.G.S.,

CORRESPONDING MEMBER OF THE ROYAL SOCIETY OF SCIENCES OF LIÈGE, THE SOCIETY OF NATURAL SCIENCES OF NEUFCHATEL; PRESIDENT OF THE GEOLOGICAL SECTION OF THE BRITISH ASSOCIATION, 1875; VICE-PRESIDENT OF THE COTTESWOLD NATURALISTS' FIELD CLUB; CONSULTING SURGEON TO THE CHELTENHAM HOSPITAL; AND MEDICAL OFFICER OF HEALTH FOR THE URBAN SANITARY DISTRICTS OF CHELTENHAM, CHARLTON-KINGS, AND LECKHAMPTON.

VOLUME FIRST.

PART SEVENTH.

ON THE ECHINOCONIDÆ, ECHINONIDÆ, ECHINOBRISSIDÆ, ECHINOLAMPIDÆ, AND SPATANGIDÆ.

PAGES 225—264; PLATES LIII—LXII.

LONDON:

PRINTED FOR THE PALÆONTOGRAPHICAL SOCIETY.

1875.

PRINTED BY
J. E ADLARD, BARTHOLOMEW CLOSE.

other specimens exhibiting the jaws have been discovered. The teeth are small, smooth, white, lanceolate, triangular, each consisting of a concave lamina, terminating below in the dental point, and strengthened by a prominent ridge behind (fig. 6).

The base is flat, and both areas are covered with much larger tubercles than those developed on the dorsal surface; they are arranged in irregular concentric rows around the peristome; the single inter-ambulacrum is elongated posteriorly, and more tumid towards the border, which is sometimes rostrated and recurved (Pl. XLIX, fig. 2 and fig. 4, and Pl. L, fig. 1 and fig. 2). In this portion the vent opens; this aperture is one third larger than the mouth, and broadly elliptical in a longitudinal direction; its margins are thick and elevated, and appear to have supported an anal membrane. The vent is marginal in a majority of specimens, and is rarely seen above the border; most frequently it cuts that angle obliquely (Pl. L, figs. 1 and 2).

The apical disc (Pl. L, fig. 1 *e*) is quadrangular, and formed of four perforate and one small imperforate ovarial plates; the right antero-lateral is the largest, and extends into the centre of the disc, its surface supports the madreporiform body; the five ocular plates are small cordate elements, closely wedged in the angle between the ovarials.

Affinities and Differences.—This typical species differs from its congeners in its form, which is always conical or pyramidal; the base is flat and sub-pentangular, and the single inter-ambulacrum is posteally produced, being somewhat tumid and recurved. These characters readily distinguish it from *E. castanea.* The straight, slightly inclined sides, the acute ambital angle, and flat base, form a good diagnosis between it and *E. subrotundus*, which has convex sides, a rounded ambital border, narrow base, and small inter-ambulacrum; the conical form, small tubercles, and large vent distinguish it from *E. abbreviatus.*

Locality and Stratigraphical Position.—This species is found in abundance in the white Medial Chalk of the English Cretaceous districts. It is very Common in the south; fine specimens are obtained at Gravesend and other localities in Kent, and at Swaffham, in Norfolk. Specimens showing the dentiferous jaws are in the collections of Mr. Stokes, Dr. Bowerbank, and my kind friend the Rev. T. Wiltshire, F.G.S.; to whom I am indebted for the figured specimen.

Foreign Localities.—In France, according to M. Cotteau, it is found in l'Étage Sénonien, at Meudon, near Paris, near Sens, Villeneuve-le-Roi, and Charny, Yonne; Beauvais and Roquemont, Oise; Chartres, Eure-et-Loire; Vernonnet and Pinterville, Eure; Bains-de-Rennes, Aude; the environs of Aix-la-Chapelle, and in the Island of Ruëgen.

Echinoconus abbreviatus, *Desor.* Pl. LII, fig. 2 *a—i*; Pl. LIII, fig. 1.

Conulus globulus,		*Klein.* Nat. dispositio Echinodermatum, p. 25, tab. xiii, c, d, e, f, var. α, *Wagricus;* tab. xiv, *c, d, e, f,* var. β, *Gedanensis*, 1734.
—	nodus,	*Klein.* Idem., tab. xiv, *g, h, Gottlandicus,* 1734.
—	bulla,	*Klein.* Idem., tab. xiv, *i, k, Gedanensis,* 1734.
Echinites vulgaris,		*Leske* (pars), *Klein.* Echin., tab. xiii, c, d, e, f; tab. xiv, c, d, e, f, 1778.
—	—	*Gmelin.* Syst. Naturæ, p. 3182, 1789.
—	—	*Bruguière.* Encycl. Méthod., tab. 153, figs. 6, 7, 1791.
Galerites	—	*Lamarck* (pars). Syst., p. 347, 1801.
—	—	*Lamarck.* Animaux sans Vertébres, t. iii, p. 20, 1816.
Echinites	—	*Schlotheim.* Die Petrefakten, p. 320.
Galerites truncatus,		*Defrance.* Dic. Sc. Nat. Galérites, t. viii, p. 87.
—	vulgaris,	*Deslongchamps.* Encycl. Méthod., p. 431, 1824.
—	—	*Goldfuss.* Petrefacta Germaniæ, tab. xl, fig. 20, 1829.
—	—	*Woodward.* Geology of Norfolk, pl. v, fig. 2, 3, 1833.
—	—	*Blainville.* Manuel d'Actinologie, p. 222, 1834.
—	pyramidalis,	*Desmoulins* (pars). Études sur les Échinides, p. 248, 1837.
—	abbreviata,	*Desor.* Monographie des Galérites, tab. iii, figs. 9—17, p. 20, (*non* Lamarck), 1816.
—	—	*Agassiz* and *Desor.* Catal. raison., p. 90 (modèles s. 65, s. 70).
—	vulgaris,	*d'Orbigny.* Prod., t. ii, p. 272, 1847.
—	abbreviatus,	*Forbes* (pars). Mem. Geol. Soc. Survey, decade iii, pl. viii, fig. 5, 1850.
—	—	*Bronn.* Lethea Geognost. Kreid., p. 192, pl. xix, fig. 17, 1854.
—	—	*Desor.* Synopsis des Échinides Foss., p. 184, 1858.
—	—	*Morris.* Catal. of British Fossils, 2 ed., p. 80, 1854.
—	—	*d'Orbigny.* Revue de Zoologie, p. 20, 1854.
Echinoconus globulus,		*d'Orbigny.* Paléontol. Française, t. vi, tab. 999, p. 522, 1855.

Diagnosis—Test thick, elevated, conoidal or globular, margin almost circular, not angular; wider near the anterior third; base flat, rounded at the circumference; single inter-ambulacrum narrow, tumid, and recurved at the border; vent prominent, infra-marginal; primary tubercles surrounded by deeply concave areolas; miliary granules large and thickly set on the inter-tubercular spaces.

Dimensions.—Height, one inch and one tenth; length, one inch and four tenths; latitude, one inch and three tenths.

Description.—The attempt to make out the history of this Urchin has proved a perplexing and unsatisfactory task, inasmuch as the type-specimens figured by Klein were

siliceous moulds without any portion of test attached thereto, and of these he made three species, *Conulus globulus*, *C. nodus*, and *C. Bulla*. His learned commentator, Leske, in his 'Additamenta ad Kleinii Dispositionem Echinodermatum,' p. 165, groups them all into one species, which he described under the name *Echinites vulgaris*, and remarks, "Interim hae differentiæ si hæc corpora petrefacta, quæ plerumque nuclei tantum *Echinitarum* sunt, attente contemplor, mihi magis videntur a mutatione, cum in petram converterentur Echini naturales, pendere, quam veram diversitatem specierum indicare. Itaque etiam *Nodum* et *Bullam* Klenii, § 53, 54, ad varietates refero. Prout enim testa vel plus vel minus comprimeretur, eo vel obtusa, vel conica magis nascebatur figura. In multis speciminibus vertice obtuso, hic vi externa quasi impressus videtur." Lamarck, in his 'Système,' 1801, and in 'Animaux sans Vertébres,' 1816, followed Leske, and cites the Tabs. XIII and XIV of Klein's work as types of *E. vulgaris*.

Leske, in his 'Additamenta,' p. 166, describes another large mould, which he regards as a variety of *Echinites vulgaris*, and figures the same. In Tab. XL, figs. 2 and 3, of this specimen he observes, "Singularis et notatu digna varietas, tam propter brunum colorem; quam propter insignem magnitudinem est ea, Tab. XL, Van Phelsum hanc iconem interrogando cum Klenii Tab. XIII, G, H, comparat. Singulares etiam rugæ et lineæ eminentes in areis conspiciuntur. *Ambulacra* singula biporosa fuisse videntur; *os* parvum; *anus* oblongus; ambitus testæ est circularis."

Lamarck, in his 'Animaux sans Vertébres,' tom. iii, p. 20, describes this mould as a new species under the name *Galerites abbreviatus*, and cites Leske's figure as its type, but we are left in ignorance of its true specific characters, as the test is entirely wanting.

Schlotheim, Deslongchamps, Goldfuss, d'Blainville, Desmoulins, and Milne-Edwards, in their several works, have followed Lamarck.

Professor Desor, in his 'Monographie des Galerites,' first gave capital figures in Tab. III, fig. 9—17, and a concise description of a large Urchin with the test entire, and interior moulds of the same from the collection of M. de Luc. The specimens were collected from the detritic sands of Stada, in North Germany; he considers these moulds to be the same species which Klein figured as *Conulus globulus*, *C. nodus*, and *C. nodosa* in his 'Dispositio Echinodermatum,' Tab. XIII, fig. D—H. The specimen with the shell was a unicum and has been valuable as helping us to a knowledge of the moulds which have occasioned so much confusion in our synonymy.

Mr. S. Woodward, Sen., in his 'Memoir of the Geology of Norfolk, has figured two varieties of this Urchin as *Galerites vulgaris*, α, β. The specimens Mr. Bone has drawn for this work were obtained from the same chalk pits as those from whence Mr. Woodward's fossils were collected, and these Norwich specimens agree so well with Desor's figure that there is no doubt about their identity with M. de Luc's Urchin.

M. d'Orbigny, in his 'Palæontologie Française,' described and figured this species under the name *Echinoconus globulus*, Klein, which, I admit, would have been correct in accordance with the principle of priority which has guided our nomenclature of species

had only one species been so named, but as Klein described three species out of what now appears to be mere varieties of one form in my judgment it is wiser, for the sake of clearnesss and precision, to avoid the revival of either of his names, as it is uncertain to which variety the name *globulus* should be strictly applied.

In order to define accurately this species, I have determined to adopt Professor Desor's figures and description as the type retaining the specific name *abbreviata* without reference to the mould to which it was first applied.

The test is round, not angular at the border, moderately elevated; convex or subconoidal, a little wider anteriorly, its greatest latitude being across the antero-lateral ambulacra, the sides are unequally inflated, the posterior half being more protuberant than the anterior half, owing to the apical disc being excentral and situated a little forwards (Pl. LII, fig. 2 *c*, Pl. LIII, fig. 1); the base is flat, the mouth-opening small, round, and prominent; the vent larger and opening into a recurved prominence formed by the single inter-ambulacrum (Pl. LII, fig. 2 *b*, *d*).

The ambulacral areas are narrow (Pl. LII, fig. 2 *e*) and built up of a column of small plates, of which four correspond in height to one inter-ambulacral, the outer border of each pair of microscopic pedal plates are united, and in each of these a pair of pores are set obliquely. The anatomy of the pedal plates forming the poriferous zones is more satisfactorily exposed in the specimen now under examination than I have hitherto seen them, and clearly shows that the poriferous zones are a portion of the test distinct from the plates forming the inter-ambulacra and ambulacra between which they are interposed, each pair of holes being formed, for the passage of the tubular feet, by the growth of a pair of plates around the exertile pedal suckers.

The inter-ambulacral areas are three times the width of the ambulacral; on each plate are three horizontal rows of tubercles, four or five in each row (fig. 2 *e*), each is surrounded by a sunken areola, encircled by granules; the boss is crenulated, and the summit of the tubercle perforated (fig. 2, *g*, *h*). The entire surface of the plates is covered with granules much larger and more numerous than in any other *Echinoconus*.

The base is flat or slightly concave, and the border rounded; the single inter-ambulacrum convex, prominent, and recurved at the margin, where the circular vent opens (fig. 2 *b*, *d*); the mouth-opening is small and central, the peristome feebly diagonal with an elevated border at the circumference.

The apical disc is small, and its plates so intimately soldered together that few specimens show the sutures (fig. 2 *i*); the disc is excentral and inclined forwards, as the slope from the disc to the anterior border is shorter than the slope from disc to the posterior border; this is owing to the great development of the single inter-ambulacrum and the prominence of the basal portion of that area (see Pl. LII, fig. 2 *c*; and Pl. LII, fig. 1). The two pairs of ovarial plates are small, their holes very large (fig. 2 *i*); and the

small single plate is imperforate; the spongy portion of the madreporiform body is small, and the surface of the other plates closely covered with granules.

One remarkable feature in the structure of this test consists in the size, number, and prominence of the miliary granules, which cover the inter-tubercular spaces and form on the sides and upper surface of well-preserved specimens a thin incrustation which coats the plates and makes the tubercles on the sides appear as punctured depressions rather than elevations of the test. Pl. LII, fig. 2 *e*, is a drawing of a portion of both areas with the zones magnified four diameters, taken from the side of the test; the inter-ambulacral plates support three rows of tubercles, four or five in each, which are situated in a depression surrounded by an areola, and have some of their bosses crenulated and summits perforated (fig. 2 *g*, *h*). The ambulacra have four rows of similar tubercles and a like abundance of close-set granules on the surface of their plates. The tubercles on the basal plates are more numerous, the areolas wider, and the granules in a great measure absent from this region of the test (fig. 2 *f*) where these large basal plates are situated, they are drawn, magnified four diameters.

The mouth-opening is very small (fig. 2 *b*), about one third less than the vent; the peristome is nearly circular, thickened and prominent like the vent, the microscopic plates of the inter-ambulacra being narrow and piled on each other produce the rounding and thickening of the peristome; the pores in the zones are unigeminal around the opening. One remarkable specimen in my collection enables me to make these detailed observations on the minute anatomy of the test of *E. abbreviatus.*

Affinities and Differences.—This species resembles *E. subrotundus* in the elevation of the upper surface and inflation of the lateral parts. A comparison, however, of the profiles of both species, as given in Pl. LII, fig. 1 *c*, and fig. 2 *c*, and Pl. LIII, fig. 1 and fig. 2 *c*, will show at a glance several distinguishing characters, the excentricity forwards of the apical disc, the shortness of the anterior slope, as compared with the greater length of the posterior, and the prominence and recurvation of the single inter-ambulacrum. In *E. subrotundus* the tubercles are larger and more numerous and the miliary granules smaller and fewer, whilst the reverse forms one of the specific characters of *E. abbreviatus;* the tubercles are small and sparse, and appear sunk in the test by the great development of the miliary granulation which forms a thin coating on the lateral and upper portions of the plates. In Pl. LII both species are admirably drawn, and the minute anatomy of the tests displayed, so that a careful examination of the figures, will place the affinities and differences between these confluent forms more clearly before the eye of the student, than the most elaborate description could convey to the mind.

Locality and Stratigraphical Position.—All the examples of this species that I have examined were collected from the Upper Chalk at Harford Bridge, Trowse, and Trimmingham, Norfolk, where it is known as a leading fossil of the Norwich Chalk.

Echinoconus globulus, *Desor*. Pl. XLIX, fig. 1 *a—g*.

Galerites globulus, *Desor*. Monographie des Galerites, tab. iv, figs. 1—4, p. 18, 1842.
— — *Forbes*. In Morris, Catalogue of Brit. Foss., 2nd ed., p. 80, 1854.

Diagnosis.—Test small, nearly globular; base narrow; border rounded; vent elliptical and supra-marginal; inter-ambulacral plates sparsely covered with primary tubercles.

Dimensions.—Height, six tenths of an inch; length, eight tenths; latitude, seven tenths.

Description.—The small test figured in our Pl. XLIX was always considered to be a distinct species by the late Dr. Woodward; it is identical with the form first described and figured by Professor Desor, in his 'Monograph on the Galerites;' the specimen, in fact, which served as the type of Desor's figure belonged to the collection of M. de Luc, who obtained it from the English White Chalk; at first sight it appears to be a young specimen of *E. subrotundus;* a closer examination, however, shows it differs in essential points from that form. The test is slightly elongated, and is nearly globular in consequence of the narrowness of the base, and the rounding of the border; the posterior carina is not prominent, the vent is elliptical and quite supra-marginal, but in consequence of the rounding of the border this aperture is visible both from the base and upper surface. The ambulacral areas are built of very narrow plates and have four rows of tubercles arranged obliquely on the area, one tubercle from the inner row alternating with a tubercle on the outer row; the poriferous zones are very narrow, the pores unigeminal and oblique, six pairs being opposite one large plate (fig. 1 *e*).

The inter-ambulacral areas are twice the width of the ambulacral; each of the plates supports five or six tubercles arranged in quincuncial order, and the inter-tubercular surface is covered with microscopic miliary granules, of which a capital sketch is given in fig. 1 *e;* at the border and base the granules form regular circles around the tubercles, as seen in fig. 1 *g*. Both these drawings are magnified six diameters.

The apical disc is large and well developed in this small Urchin (fig. 1 *f*); the right antero-lateral ovarial is the largest plate in the disc and extends into the centre; it is covered with the spongy body, and the other three ovarials forming the two pairs are small and of the same size; they are perforated near their apices, and the small posterior single ovarial is imperforate; the five ocular plates are all well perforated.

The mouth-opening is small and central, and the peristome less in diameter than the supra-marginal elliptical vent.

Affinities and Differences.—The globular shape of this Urchin resembles some forms

of *E. subrotundus*, of which it may be only a variety; it has, however, fewer tubercles on the inter-ambulacral plates, and the vent is much higher up on the test than in that species. Its globose form presents a remarkable contrast to the conical *E. conicus*, the elongated *E. castanea*, and the recurved posterior base of *E. abbreviatus*.

Locality and Stratigraphical Position.—This very rare species is found in the Upper White Chalk with flints at Gravesend and in Kent. The test I have figured is contained in the British Museum.

Genus—Holectypus, *Desor*, 1847.

Discoides (pars), *Klein*, 1734.
Echinites (pars), *Leske*, 1778.
Galerites (pars), *Lamarck*, 1816.
Discoidea (pars), *Gray*, 1835.

The Genus *Holectypus* was established by M. Desor for the reception of those Discoideæ which are deprived of ribs or projecting processes on the inner wall of the test. The species referred to this group constitute one of the oldest types of the Echinoconidæ, and are met with chiefly in the Oolitic rocks. They form, according to the views of the late Professor Forbes, "a section or sub-genus of the *Galerites*, more valuable on account of their palæontological merits, and limited distribution in time, being in the main characteristic of the Oolitic period, than for the zoological importance of the character of their organization, which are rather transitional than distinctive."

The test is thin, circular, or sub-circular, more or less hemispherical, conical, or sub-conical, always tumid at the sides, and flat or concave at the base.

The ambulacral areas are narrow, straight, and lanceolate, with six or eight rows of small tubercles, of which the marginal series only extend from the base to the apex.

The poriferous zones are narrow, and the pores are unigeminal throughout.

The inter-ambulacral areas are three times the width of the ambulacral; the large pentagonal plates support numerous, small, perforated tubercles, which are very regularly arranged in vertical and concentric rows. They are raised on bosses with crenulated summits and surrounded by ring-like areolas; numerous minute granules are scattered over the surface of the plates and form circles around the tubercles.

The mouth-opening is circular and situated in the centre of the base; the peristome is divided by obtuse notches into ten equal lobes. The organs of mastication consisted of five jaws, which are preserved *in sitû* in one specimen I collected from the Forest Marble of Wilts.

The anal opening is large, inferior, infra-marginal, rarely marginal, sometimes occupying the entire space between the mouth and the border.

The apical disc is nearly central and vertical, composed of five ovarial and five ocular plates; the right antero-lateral ovarial is much the largest and extends into the centre of the disc; it supports a prominent, convex, madreporiform body. In all the Oolitic species the anterior and posterior pairs of ovarials are perforated, and the single plate imperforate; whilst in all the Cretaceous species the five ovarial plates are all perforate, and the five ocular plates are small, triangular bodies, with marginal perforations (fig. 1 *i*).

The internal moulds of *Holectypus* want those depressions occasioned by ribs projecting from the inner walls of the test which so well characterise the genus *Discoidea*.

The spines are short, with a smooth head and milled ring, and they have the surface sculptured with fine longitudinal lines.

Holectypus is distinguished from *Echinoconus* by having a larger mouth and vent, a concave base, and a less elevated dorsal surface; and from *Discoidea* in having tumid sides, a larger mouth and vent, and the absence of ribs from the internal walls of the test.

The small crenulated tubercles and basal vent, with the absence of any aperture in the upper surface of the inter-ambulacrum, distinguishes *Holectypus* from *Pygaster;* and the want of a longitudinal valley in the inter-ambulacrum separates *Holectypus* from *Hyboclypus* and *Galeropygus*.

The Genus *Holectypus* is most abundant in the Oolitic rocks; the Cretaceous rocks of France contain seven species: one is special to the Neocomian, one to the Aptien, three to the Cenomanian, and two to the Turonian stages. I now add a new species from the Chloritic Marl of England, and the first of this genus from the chalk found in the British Islands.

The Genus *Holectypus* forms two natural groups, both organically and stratigraphically distinct from each other. The apical disc in one group has only four of the ovarial plates perforate; in the second group all the five ovarials are so. The species with the four perforate ovarials are all Jurassic, and those with the five perforate ovarials are Cretaceous.

HOLECTYPUS BISTRIATUS, *Wright*, sp. nov. Pl. LXV, fig. 3 *a*, *b*, *c*.

Diagnosis.—Test sub-circular, sub-conoidal, depressed on the upper surface, and flattened at the base; ambulacra lanceolate, with four irregular rows of small tubercles; poriferous zones straight, narrow, with a smooth nude band extending from the disc to the border on the inter-ambulacral side of each zone. Inter-ambulacra wide, plates narrow, with horizontal rows of small tubercles on each, apical disc small.

Dimensions.—Height eight tenths of an inch; breadth one inch and eight tenths of an inch.

Description.—This rare Urchin was collected many years ago from the Chloritic Marl, near Chard, by Mr. Weist, and kindly communicated for this work. It was long considered to be a depressed variety of *Discoidea cylindrica.* In developing the specimen, however, I displaced a portion of the test, which disclosed the inner surface and the mould, and it then became evident that the Urchin was not a *Discoidea*, but a true *Holectypus*, as it had none of the internal ribs at the ambitus which distinguish *Discoidea;* it is the first *Holectypus* that has been recorded from the Cretaceous rocks of England.

The test is sub-circular, thin at the ambitus and depressed on the upper surface (fig. 3 *b*); the ambulacral areas are lanceolate, with four or six rows of small tubercles disposed in a zig-zag manner on alternate plates of the area which are very narrow, five of them in vertical height being equal to one inter-ambulacral plate. The poriferous zones are narrow, the pores small, and unigeminal, one pair of pores corresponding to one ambulacral plate (fig. 3 *c*) magnified twice.

The inter-ambulacral areas at the ambitus are nearly three times the width of the ambulacra; the columns are built of narrow plates, each supporting a horizontal row of small tubercles, seven to eight in a row near the ambitus and fewer up the sides, each tubercle is surrounded by a narrow areola, the boss of which is crenulated and the summit perforated. The only specimen I have seen is the one under examination; unfortunately, the surface of the test is so much rubbed that its minute structure can only be made out by selecting those parts of the plates which are best preserved for careful study with the glass. The tubercles are very small and numerous, and the horizontal rows they form fill up the greater portion of the surface of the plates, so that the number of miliary granules is inconsiderable. On each side of the inter-ambulacra, separating the tubercular surface from the poriferous zones, two smooth nude bands extend from the ambitus to the disc. These naked calcareous ribbons are very well seen on one of the areas, and this bistriated structure forms a specific character of some value and from which the specific name is derived.

The apical disc is small, and the five ovarial plates are all perforated; the spongy body is much rubbed and the ocular plates so blended with the other elements that their individual character cannot be seen.

The base is covered with the matrix, which adheres so firmly to the test that it is impossible to effect its separation from the surface without at the same time removing the shell. The anatomy of this region is, unfortunately, at present unknown.

Affinities and Differences.—This species very much resembles *Holectypus Cenomanensis*, Guéranger both in the general outline of the test, the smallness of its tubercles, and in the manner they are disposed on the plates. It is found likewise in nearly the same horizon of the Cretaceous rocks. The only difference I can detect is the presence of the nude ribbon-like bands on the outer side of the poriferous zones, no indication of which is given in M. Cotteau's beautiful and carefully drawn figures.

Locality and Stratigraphical Position.—Collected from the Chloritic Marl near Chard, with *Catopygus columbarius*, *Pyrina Desmoulinsii*, *Cottaldia Benettiæ*, and other Upper Greensand forms.

Family 7.—Collyritidæ, *d'Orbigny*, 1853 (not yet found in British Cretaceous strata).

Family 8.—Echinonidæ, *Wright*, 1856.

Test thin, oval; poriferous zones narrow, meeting at the apical disc; pores unigeminal; tubercles of both areas nearly equal in size, but neither perforated nor crenulated; spines stout, subulate. Mouth-opening nearly central, irregularly pentagonal and edentulous. Vent oblong or pyriform, basal or marginal, closed by anal plates; apical disc nearly central, four ovarial plates perforated, one imperforate. Oculars microscopic, tubercles small and imperforate.

The existing forms belong to the genus *Echinoneus* of Van Phelsum, instituted under the Dutch name *Egelschuitze*, and adopted by Leske, Lamarck, Deslongchamps, De Blainville, and Desor, to include certain living species of small thin-shelled Urchins, with an oval form and a rounded and inflated border. The ambulacral areas are narrow and lanceolate; the poriferous zones depressed, and the pores small and unigeminal throughout; the upper surface is flattened, and the apical disc small and excentral; the two pairs of genital plates are perforated, and the single posterior plate is imperforate; the base is concave and curved from before backwards; the mouth-opening small, oblong,

oblique, and nearly central; the peristome entire and without auricles, and therefore edentulous. A diagnostic character of the family is the periprocte, which is basal and pyriform, about the same size as the peristome, and situated between the border and the mouth. The tubercles are small and numerous, disposed in regular series, and raised upon smooth circular elevations, with perforated summits; in this we discover another organic difference between the Echinonidæ and the Echinoconidæ. The Echinonidæ inhabit the seas of the Antilles, the Philippines, the Trinity, Cuba, Zanzibar, and New Zealand, and tests of the same species are found in a semi-fossil state in the calcareous tufa of Guadeloupe, Cuba, and Porto-Rico.

The fossil species are included in the genus *Pyrina,* which are all found in the different stages of the Cretaceous rocks.

Genus—Pyrina, *Desmoulins,* 1837.

Pyrina, Globater, and Nucleopygus, *Agassiz,* 1837.

Test oval or round, depressed or globular, sometimes pentagonal or enlarged before and narrow behind. Under surface inflated and often depressed around the mouth-opening, which is oval, oblique, and inclined from the right to the left side; this aperture is nearly central, and destitute of lobes and auricles. The apical disc is small, compact, and nearly central; it is composed of four perforated genital plates, of which the right antero-lateral is the largest, extending into the middle, and supporting the small madreporiform body. The five small ocular plates are closely wedged into the angles formed by the genitals, all the elements of the disc being soldered together. The vent is oval and marginal, in general nearer the upper than the under surface. The poriferous zones form straight equal narrow linear depressions, all composed of simple pores in regular pairs extending from the peristome to the disc. The tubercles are mammillated and imperforate, larger at the under side, and the inter-tubercular surface of the plates is covered with a great number of granules.

Pyrina differs from *Echinoconus* in having in general an elongated form, the apical disc has only four genital plates, the mouth is oval, oblique and edentulous; the vent is marginal, and the tubercles are imperforate, whereas in *Echinoconus* the disc has five genital plates, the mouth is circular or slightly pentagonal, and provided with dentiferous jaws; the vent is basal or infra-marginal, and the tubercles are mammillated with crenulated bosses and perforated summits.

PYRINA DESMOULINSII, *d'Archiac*, 1847, Pl. LIV, fig. 2 *a—i*.

PYRINA DESMOULINSII, *d'Archiac*. Mém. de la Soc. Géol. de France, 2e série, tome ii, p. 297, pl. xiii, fig. 4, 1847.
— — *Agassiz* et *Desor*. Catal. raisonné, p. 92, Modèle T. 86, 1847.
— — *d'Orbigny*. Prodrome, t. ii, p. 178, Étage No. 651, 1847.
— — *Woodward*. Mem. of the Geol. Surv., Organic Remains, Decade v, pl. vi, fig. A, 1856.
PYRINA PRATTII, *Forbes*. Morris Catal. Brit. Foss., p. 88, 1854.
— DESMOULINSII, *d'Orbigny*. Paléontol. Française, tome vi, p. 467, pl. 981, figs. 7—11, 1855.

Diagnosis.—Test tumid, oblong; ambitus inflated; posterior border slightly emarginate; upper surface depressed; apical disc small, nearly central; base concave in the middle and pulvinated at the border; mouth-opening oval, oblique, and nearly central; periprocte elliptical, supra-marginal, nearer the upper than the under surface.

Dimensions.—Antero-posterior diameter one inch; height half an inch.

Description.—The test of this rare Urchin is oblong or elliptical, regular and symmetrical, depressed on the upper surface, inflated round the sides, and concave near the centre of the under surface. The summit is sub-central, nearer the anterior than the posterior border. The ambulacral areas are narrowly lanceolate; the poriferous zones are linear and depressed, and the pores minute, unigeminal, and placed in oblique pairs. In passing across the base the geminal pores become more and more oblique, until they fall into a single file and terminate around the peristome. The plates of both areas support a number of small equal-sized tubercles; in fig. 2 *e* is shown their mode of arrangement on the ambulacral and inter-ambulacral areas; they have a quincuncial disposition on the plates. The areal space around each is sharply defined, the tubercle is raised on a boss, and its summit is perforated. The intermediate surface of the plates is covered with a very fine microscopic granulation (fig. 2 *g*). The tubercles at the base are much more developed than those on the upper surface of the test. Fig. 2 *h* and fig. 2 *i* show the basal tubercles magnified; the areal space is deeply excavated out of the structure of the plate, and the tubercle is larger than those on the upper surface at fig. 2 *i*. A portion of the test near the mouth-opening is shown with the arrangement of the zones and the disposition of the tubercles in this region.

The mouth-opening is large, elliptical, elongated in the direction of its greatest axis, slightly oblique (fig. 2 *b*), and situated immediately beneath the organic summit.

The vent is elliptical, and placed in the middle of the posterior border (fig. 2 *d*), nearer the upper than the under surface (fig. 2 *a*).

The apical disc is small, and composed of four ovarial plates, of which the right antero-lateral is much the largest, and supports a spongy madreporiform body. All these plates are perforated (fig. 2 *f*). The ocular plates, five in number, are small, and well wedged in between the ovarials.

Affinities and Differences.—The regular elliptical elongated form of *Pyrina Desmoulinsii*, with its flattened upper surface and pulvinated base, distinguish this species from its congeners. I have compared specimens obtained from the Étage Cénomanien of the environs of Tournay, Belgium, with specimens collected from the Chloritic Marl at Chard, and find them to be identical in all their details. It very much resembles *Pyrina ovulum*, which, however, is a smaller form, with a more inflated test, and the elliptical vent is situated near the dorsum. Compare fig. 2 and fig. 3, where the affinities and differences are well shown in the admirable figures in Pl. LIV.

It differs from *Pyrina lævis* in having a narrower test of a more regular elliptical figure, and wants the inflation of the anterior portion and the tapering of its posterior border.

Locality and Stratigraphical Position.—This rare Urchin was collected by Mr. Weist, in the Chloritic Marl, near Chard, and Mr. Pratt obtained another from the same locality and stratum, which has been beautifully figured in the 'Memoirs of the Geological Survey,' Decade v, pl. vi. The short description was from the pen of my old esteemed friend Dr. Woodward, to whom I forwarded all my materials when he was engaged in writing the text for the description of pl. vi of that Decade.

PYRINA OVULUM, *Lamarck*, sp. Pl. LIV, fig. 3 *a*—*h*.

NUCLEOLITES OVULUM, *Lamarck*. Anim. sans vert., t. iii, p. 37, 1816.
— — *Deslongchamps*. Encycl. Méthod., t. ii, p. 500, 1824.
— — *Defrance*. Dic. des Sc. Nat., t. xxxv, p. 213, 1825.
PYRINA — *Agassiz*. Cat. Syst., p. 7, 1840.
NUCLEOLITES — *Desor*. Mon. des Galerites, p. 26, pl. v, figs. 35—37, 1842.
— — *Agassiz* et *Desor*. Cat. rais. des Échinides, p. 92, 1842.
— — *d'Orbigny*. Prodrome, t. ii, p. 271, 1847.
— — *Morris*. Catal. of British Fossils, 2 ed, p. 88, 1854.
— — *Woodward*. Mem. Geol. Surv., Decade v, pl. vi, 1856.
— — *Cotteau*. Paléontologie Française, pl. 985, figs. 7—11, tome vi, p. 484, 1855.

Diagnosis.—Test small, inflated, depressed at the upper surface. Ambitus elliptical, base flattened, margin much inflated; mouth irregular, pentagonal, oblique, situated in the middle of the base; posterior border sulcated, vent elliptical, elevated near the upper surface, plates closely covered with small tubercles.

Dimensions.—Antero-posterior diameter four tenths of an inch; height three tenths of an inch.

Descriptions.—The test of this rare little *Pyrina* is oblong-oval, inflated, rounded before, and sulcated behind, for lodging the vent. In its longitudinal profile, fig. 3 *d*, the test is higher behind than before, and always more or less truncated, the upper surface is convex and slightly flattened, the under surface is convex and pulvinated, without a depression in the centre, the plates are covered with numerous small tubercles larger on the under surface, the areas are excavated to receive the boss, which carries a small perforated tubercle, fig. 3 *g* and *h*. The apical disc is small, composed of four perforated ovarial plates and five very minute oculars, fig. 3 *f*. The mouth opening is situated in the middle of the base, fig. 3 *c*, and forms an irregular pentagon with its long axis oblique. The vent is oval, situated in a sulcus high up in the posterior border, and the periprocte is much nearer the upper than the under surface, fig. 3 *b*, and fig. 3 *e*. The poriferous zones are extremely narrow, and appear like fine depressed lines on the surface of the shell.

Affinities and Differences.—This species differs from *Pyrina Desmoulinsii* in having the posterior border sulcated for the vent which occupies a higher position in this Urchin.

Locality and Stratigraphical Position.—It is said to have been collected from the lower chalk of Dorsetshire. In France M. Cotteau records it from l'Étage Sénonien, he collected it in that formation at Saint Christophe, and at Tours, Indre-et-Loire, and at Villedieu, Loir-et-Cher.

PYRINA LÆVIS, *Agassiz*, 1840. Pl. LIV, fig. 1 *a—e*.

GALERITES LÆVIS, *Agassiz.* Cat. Syst., p. 7, 1840.
— — *Desor.* Monographie des Galerites, p. 24, pl. iv, figs. 8—11, 1843.
— — *Agassiz.* Cat. rais., p. 91, Modèle 79, 1847.
— — *d'Orbigny.* Prodrome, t. ii, p. 272, 1847.
ECHINOCONUS — *d'Orbigny.* Revue Zoologique, p. 21, 1854.
PYRINA — *Cotteau.* Paléontol. Française, t. vi, p. 490, pl. 987, figs. 6—9, 1855.

Diagnosis.—Test subpentagonal, enlarged anteriorly and contracted posteriorly,

convex above, inflated at the sides and flattened below; vent large, supra-marginal, elliptical; mouth-opening central, opposite the disc; tubercles small, surface of the plates smooth.

Dimensions.—Anterior posterior diameter eleven twentieths of an inch; height seven twentieths of an inch.

Description.—This little Urchin appears to be a very rare form, as the example before me is the only specimen I have seen in English collections; the type specimen figured by my friend Professor Desor, in his Monograph on the Galerites belonged to M. Deshayes and was the only one known to him.

M. Cotteau has not seen the original, giving copies of Prof. Desor's figure of the test and quoting his description of its structure in his 'Paléontologie Française.' My specimen was collected several years ago from the Upper Greensand near Chute farm, Wilts, along with some fine examples of *Catopygus columbarius* and *Cottaldia Benettiæ*, so that there is no doubt of the horizon of the English specimen. The general outline of the test is indistinctly pentagonal, enlarged before and slightly narrower behind (fig. 1 *b* and fig. 1 *c*). The upper surface is convex, the sides inflated, and the base flat (fig. 1 *a*; fig. 1 *e*); its height is about one half the length of the test. The plates are covered with small tubercles, which are very indistinctly seen; those at the base are larger. The vent occupies the middle of the border; the periprocte is large, of an elliptical shape, and placed a little nearer to the base than the upper surface. The sur-anal carina is only slightly developed around the lower part of periprocte. The lower surface is nearly flat, with the margin round, and the small mouth-opening is situated in the middle of the base directly opposite the vertex.

Affinities and Differences.—This species is readily distinguished from *Pyrina Desmoulinsii* by its sub-pentagonal form enlarged before and contracted behind; its sides are likewise more inflated and the lower angle of the periprocte is nearest the base, whilst in *P. Desmoulinsii* the upper angle of that aperture is nearest the dorsal surface.

Locality and Stratigraphical Position.—I collected this Urchin from the Upper Greensand of Chute Farm, near Wilts, with *Catopygus columbarius, Cottaldia Benettiæ*, and other well-known forms of Urchins and Mollusca belonging to that stratum.

The type figured by M. Desor was obtained from the Cretaceous rocks of France, and as it was communicated to M. Desor by M. Deshayes without the indication of the formation from whence it was collected, we are unfortunately in ignorance of its stratigraphical position, and as M. Cotteau had not seen the specimen, he was unable to give an opinion on the matter.

Family 9—Echinobrissidæ, *Wright*, 1856.

Test thin, circular, oblong, sub-pentagonal, or clypeiform, covered with microscopic perforate or imperforate tubercles, surrounded by excavated areolas; ambulacra narrow, enclosed by poriferous zones more or less petaloidal; pores set at different distances apart, and united by connecting sutures. Mouth-opening small, nearly central, pentagonal, edentulous, and in general surrounded by five lobes. Vent-opening in a sulcus in the upper surface of the single inter-ambulacrum, or in a marginal depression or basal portion thereof; apical disc small, with four perforate and one imperforate genital plate; ocular plates very small; madreporiform body extending into the centre of the disc. This family is extremely numerous in genera and species; two of its representative forms are still living—*Echinobrissus recens*, Edwards, in the Antilles, and *Cassidulus Australus*, Lamarck, in the Australian seas.

I include the following genera in this natural family:

Catopygus, *Agassiz*.
Clypeopygus, *d'Orbigny*.
Clypeus, *Klein*.
Echinobrissus, *Breynius*.
Phyllobrissus, *Cotteau*.
Botriopygus, *d'Orbigny*.
Trematopygus, *d'Orbigny*.
Rhynchopygus, *d'Orbigny*.
Cassidulus, *Lamarck*.
Caratomus, *Agassiz*.

Genus—Catopygus, *Agassiz*, 1837.

Nucleolites, *Lamarck, Goldfuss*.

Diagnosis.—Test oval or elongated, in general inflated, narrower anteriorly than posteriorly; upper surface convex, summit excentrical anteriorly; under surface flat or slightly convex, and rounded at the border; posterior half of the test much higher and wider than the anterior half; vent situated in the posterior border; periprocte small, round, or oval, placed high in a prominent projection of the inter-ambulacrum at the summit of a vertical truncation of the area. Mouth-opening small, situated nearer the anterior than the posterior border; pentagonal in form with equal elongated sides, having one angle anterior, and surrounded by five prominent lobes (Pl. LV, fig. 2 *h*); between the lobes a rosette is formed of five depressed leaves, crowned with minute granules and unequal

buccal pores, some double externally, others small internally. Ambulacra narrow, sub-petaloid, straight, more or less elongated, and open at the lower extremity; poriferous zones composed of an inner series of round pores, and an external series of elongated pores arranged in conjugate pairs (fig. 2 *g*); tubercles very small, raised on mammillated bosses (fig. 2) in many horizontal lines on the surface of the dorsal plates, those at the base being larger. Apical disc small, prominent, formed of four perforated ovarial plates and five microscopic oculars, the madreporiform body projecting from the surface (fig. 2 *f*).

Affinities and Differences.—*Catopygus* differs from *Clypeopygus* and *Echinobrissus* by its oval form, convexity of the upper surface, inflation of the sides, and flatness of the base, by its pentagonal mouth, with five prominent sides and rosette of pores between the lobes, and its small round periprocte opening high in a prominent vertical truncation of the single inter-ambulacrum.

The genus *Catopygus* appertains to the Cretaceous rocks, and is a very characteristic fossil in its different divisions. In the Gault or Albian stage of the Mediterranean basin *Catopygus cylindricus* has only hitherto been found.

In the Upper Greensand or Cenomanian formation *C. columbarius* prevails throughout the Anglo-Parisien and Mediterranean basins.

In the Lower Chalk or Turonian *C. Ebrayanus* is found.

In the Middle Chalk or Senonian eight species have been collected in France, where many of the beds of this division attain a development unknown in England, and contain a fauna of the most remarkable forms. The *C. sub-carinatus* and *elongatus* are found simultaneously in the Anglo-Parisian and Pyrenean basins, although *C. lævis, fenestratus, conformis, pyriformis, obtusus,* and *affinis,* are discovered only in the Parisian basin.

This genus, therefore, attained its greatest development in the seas which deposited the White Chalk with flints, and became extinct with the close of the Cretaceous epoch, as *Catopygus* is not found in the Tertiary rocks nor in the waters of the present time.

Catopygus columbarius, *Lamarck,* 1816. Pl. LV, fig. 2 *a*—*i*.

Echinites pyriformis, *Parkinson.* Organic Remains, vol. iii, tab. iii, fig. 6, 1811.
Nucleolites columbaria, *Lamarck.* Anim. sans Vertèbres, t. iii, p. 37, 1816.
— — *Deslongchamp.* Encyl. Méthod., t. ii, p. 570, 1824.
— — *Defrance.* Dic. des Sciences Nat., t. xxxv, p. 313, 1825.
— carinatus, *Goldfuss.* Petrefacta Germaniæ, b. i, p. 142, pl. xliii, fig. 11, 1826.
— columbaria, *Blainville.* Dic. des Sciences Nat., t. lx, p. 188. 1830.

Catopygus carinatus,	*Agassiz.*	Prodrome Échinides, p. 18, 1836.
Nucleolites columbaria,	*Desmoulins.*	Études sur les Échinides, p. 356, 1837.
— carinatus,	*d'Archiac.*	Mém. Geol. Soc. de France, p. 180, 1837.
Catopygus —	*Bronn.*	Lethæ Geognostica, p. 613, 1837.
— —	*Milne-Edwards.*	In Lamarck, 2e éd., t. iii, p. 351, 1840.
Nucleolites columbaria,	*Ibid.*	Ibid., 344.
Catopygus carinatus,	*Agassiz.*	Cat. Syst., p. 4, 1840.
— —	*Roemer.*	Norddeuts-Kreide-Gebirges, p. 32, 1840.
Catopygus carinatus,	*Morris.*	Catalogue of British Fossils, p. 49, 1843.
— columbarius,	*d'Archiac.*	Mém. Soc. géol. France, p. 296, 1847.
— —	*Agassiz* et *Desor.*	Cat. raison., p. 100, Modèle R 71 1847.
— —	*d'Orbigny.*	Prod., t. i, p. 178, Étage 20, 1847.
Nucleolites carinatus,	*Forbes.*	Mem. Geol. Surv., Decade i, pl. 10, 1849.
Catopygus —	*Sorignet.*	Oursins de l'Eure, p. 43, 1850.
Nucleolites —	*Quenstedt.*	Handbuch der Petrefact., p. 586, pl. xlix, fig. 51, 1852.
Catopygus —	*Bronn.*	Leth. Geogn., 2 ed., p. 196, pl. 29^3, fig. 16, 1852.
— —	*Albin Gras.*	Catal. des Corps org. de l'Isère, p. 40, 1852.
— —	*Morris.*	Catal. of British Fossils, 2 ed, p. 74, 1854.
— columbarius,	*Cotteau.*	Pal. Franç. Ter. Crét., t. vi, p. 436, pl. 970, 1855.

Diagnosis.—Test oval or subrotund, contracted anteriorly, enlarged and truncated posteriorly, sides inflated, dorsal surface unequally convex, base nearly flat, ambulacra narrow, dorsal, subpetaloid and open below; inter-ambulacra wide, single inter-ambulacrum narrow, elevated, and truncated, vent round in the upper border, above the periprocte an obtuse carina which terminates in the projecting upper border of the vent; mouth-opening small, excentral nearer the anterior border, peristome surrounded by five prominent lobes and a rosette of pores between them. Apical disc excentral nearer the anterior border, the vertex in general behind the apex.

Dimensions.—I have selected six good typical forms showing the varying proportions of this species.

	1	2	3	4	5	6
Length .	1	$0\frac{11}{12}$	$0\frac{10}{12}$	$0\frac{9}{12}$	$0\frac{8}{12}$	$0\frac{7}{12}$
Height .	$0\frac{10}{12}$	$0\frac{10}{12}$	$0\frac{8}{12}$	$0\frac{6}{12}$	$0\frac{5}{12}$	$0\frac{7}{12}$
Breadth .	$0\frac{8}{12}$	$0\frac{7}{12}$	$0\frac{6}{12}$	$0\frac{6}{12}$	$0\frac{6}{12}$	$0\frac{7}{12}$

Description.—The table of synonyms exhibits the changing views of naturalists in respect to this beautiful Urchin. Goldfuss, who gave the first good figure of the species, cites, with doubt, its identity with *Nucleolites columbarius,* Lamarck, but the brief diagnosis in 'Hist. Nat. des Anim. sans Vert.,' taken in connection with the locality and stratum from whence it was collected, "les environs de Mans," so well known for its beautiful Upper-

Greensand fossils, has satisfied me, after a comparison of specimens in my collection from that locality with a series of type tests from the Upper Greensand of Wilts and Dorset, that the two Urchins appertain to the same species, and that Lamarck's name ought to be retained. *Catopygus columbarius,* it is true, assumes a considerable variation of form as regards the elongation, shortening, height, breadth, and inflation of the test, so that there is field enough for species-makers, who attach undue importance to these characters, to make several varieties out of a handful of specimens. These phases of form appear to me to have depended on the physical conditions which surrounded the life of the Urchin, and have nothing whatever to do with the specific characters I have pointed out in my diagnosis of the species.

The test is ovate or subrotund and always wider behind than before; the dorsal surface is tumid, varying in the degree of its elevation; in some specimens it is subdepressed and declines anteriorly, in others it is subconic and much elevated in the centre, the true apex being almost the apical disc, whereas, in general, that body is excentral and situated before the vertex, which is formed by the ridge of the single inter-ambulacrum. The sides are rounded and more or less inflated, and the posterior extremity is truncated more or less abruptly. A more or less developed obtuse central elevation extends along the ridge of the single inter-ambulacrum to the upper border of the vent, where it forms in many examples a prominent apiculated arch over the periprocte, Pl. LV, fig. 2 *d.* In all the specimens I have examined this prominence exists, but its degree of development varies much. The ambulacral areas are narrowly lanceolate, limited to the dorsal surface, subpetaloid, and very uniform in their proportions in all the varieties. The single area and anterior pair are nearly equidistant from each other, but the posterior pair are more distant from the anterior pair, and are placed much closer together than the others and extend backwards. The number of pairs of pores in each zone is nearly equal, varying from twenty-eight to thirty in well-grown adult shells; the pores in the outer row are elongated and oblique, and in the inner pores are round and appear to be conjugated by fine oblique sutures. At the lower part of the petals the pores become smaller, and are set much wider apart as they pass round the border of the test and extend to the peristome. The ambulacral plates are narrow in the petaloid portion of the zones, and become much larger and broader beyond the petals; each plate has its pair of holes which can be distinctly traced in good specimens, and they form the true poriferous zones on the sides and base of the test. Pl. LV, fig. 2 *b, c, d, e,* shows these poriferous zones. Around the mouth the pairs of pores again form petals as on the dorsal surface, and they are here so arranged that they form ten short petaloidal ambulacra, forming rosettes around the mouth, and constructed like those on the dorsal surface. Fig. 2 *h* shows this structure extremely well in a drawing magnified six diameters.

The wide inter-ambulacral areas are formed of large oblong plates, the surface of which, as well as those of the ambulacra, are covered with minute moniliform tubercles, interspersed with microscopic granules. Fig. 2 *g* shows the arrangement of the tubercles

and granules on the ambulacral and inter-ambulacral areas magnified six times; and fig. 2 exhibits the more developed form the tubercles assume on the basal plates, and the manner they are encircled by rows of granules. It is only on very fine specimens, such as some I have obtained from the Chloritic Marl of Chard, that I have been able to see the surface anatomy of the plates, such as I have figured and described it; the Upper-Greensand fossils are spoiled by the matrix, and are quite unfit for such minute observations.

The small apical disc is, in general, excentral, and the madreporiform body occupies the centre, covers the plates, and forms a prominence; there are four perforated genital plates, and five distinct ocular plates (fig. 2 *b* and fig. 2 *f*). The two anterior genital holes are placed nearer together than the posterior pair.

The ventral surface is slightly convex, or nearly flat; the tubercles are much larger in this region, and exhibit the arrangement shown in fig. 2 *i*, where each tubercle rises on the surface of a rounded boss and is encircled by a ring of granules (fig. 2 *c*). The mouth-opening is excentral and nearer the anterior border, the peristome is pentagonal and surrounded by five prominent tubercles which form the termination of the inter-ambulacral areas (fig. 2 *c*). From the inter-lobular spaces ten short petaloid ambulacra proceed, and these collectively form rosettes around the peristome, as shown in fig. 2 *h*, where this structure is drawn magnified six diameters.

The vent opens in the upper portion of the truncated posterior border in a well-defined vertical area; it is oblong, and varies in size in different specimens, but is always small in proportion to the size of the test.

The periprocte is prominent, especially in the upper border, which, in some specimens, overhangs the vent in a beak-shaped fashion (fig. 2 *d*).

Affinities and Differences.—This species is found in the Upper Greensand or Cenomanian stage throughout the Anglo-Parisian and Mediterranean basins, and it is the only form of *Catopygus* hitherto collected in this stratum in England; its characters are so definite and distinct that there is no difficulty in distinguishing this species from its congeners.

Locality and Stratigraphical Position.—It has been collected from the Upper Greensand of Warminster and Chute Farm, Wiltshire; Hythe, Kent; and from the junction beds of Upper Greensand and Chalk-marl at Maiden Bradley, Wiltshire; and from the Chloritic Marl, near Chard, whence my best specimens were obtained. The foreign distribution of this species, according to M. Cotteau, is from the Cenomanian or 20th stage of d'Orbigny, the equivalent of the Upper Greensand of English authors. In France it is common at Mans, Coulaines, Saint-Calais, and Condrecieux, Sarthe; Villers, Trouville, Calvados; Havre, Seine-Inférieure; Gracé, Orne; Vierzou, Cher; Chinon, Indre-et-Loire; Fouvas and Bel-Air, near Rochefort, and other localities. In Belgium in the Tourtia of Tournay; in Westphalia at Essen on the Ruhr.

Catopygus Vectensis, *Wright*, nov. sp. Pl. LV, fig. 1 *a—d.*

Diagnosis.—Test oblong, contracted posteriorly; dorsal surface flat and convex, elevated towards the narrow posterior border; sides inflated, base concave; ambulacra narrow, lanceolate, dorsal, subpetaloid, and open below; inter-ambulacra wide, single inter-ambulacrum narrow, slightly elevated; posterior border truncated; vent oblong, in the upper third; an obtuse elevation of the dorsal portion, bifurcating at the periprocte, sends down a carina on each side of the vent, which extends to the margin. Apical disc nearly central, four perforated genital plates; madreporiform body small, central.

Dimensions.—Length one inch; breadth eight tenths of an inch; height unknown.

Description.—This species has much resemblance to certain varieties of *Catopygus columbarius* but a careful comparison between it and the most allied forms of that species shows that *Catopygus Vectensis* possesses distinct characters of its own. It is, I believe, the oldest form of the genus *Catopygus* at present known. The outline of the test is nearly a regular oblong, rather more contracted posteriorly (Pl. LV, fig. 1 *a, b*). It is moderately elevated and a little higher at the posterior border (fig 1 *c*); the sides are inflated (fig. 1 *d*), and the base is concave; this portion of the test is partially covered by closely adherent matrix in the best specimen, and broken in the other, so I must speak with reservation regarding the specific characters of this region. The ambulacral areas are narrowly lanceolate (fig. 1 *b, d*), and the long subpetaloid poriferous zones extend over the dorsal surface, a character which is very well drawn in figs. 1 *a, b, c, d;* the traject line of the pores is indicated by the sutures in which they are placed, but the pores themselves cannot be satisfactorily made out in consequence of the imperfect preservation of the areal plates.

The inter-ambulacral areas are built of long plates; those on the upper surface had very small tubercles which appear to have been more developed at the base; the posterior single inter-ambulacrum has an elevated ridge on the mesial line which extends to the upper border of the vent (fig. 1 *o*), and then divides into two branches (fig. 1 *d*); which descend to the border, the whole forming a kind of miniature Gothic arch, having the oblong vent in its upper third (fig. 1 *c* and *d*).

The apical disc is nearly central (fig. 1 *b*), and lower than the vertex (fig. 1 *c*); it is small, has four genital holes drilled around a small central button-shaped madreporiform tubercle.

The mouth-opening is excentral and anterior; it is too much concealed by hard rock to be exposed without risking the fracture of the shell, so the anatomy of the peristome cannot be made out.

Affinities and Differences.—This species differs from *C. columbarius* in the following

characters :—The shell tapers behind, is not so elevated, has a flatter dorsal surface and less prominent central ridge in the inter-ambulacrum ; the apical disc is more central, and the contour indicates a flatter form with less inflated sides.

Locality and Stratigraphical Position.—This new species was collected by the Rev. T. Wiltshire, F.G.S., from the Lower Greensand (Neocomian) at Shanklin, Isle of Wight.

Genus—Clypeopygus, *A. d'Orbigny*, 1856.

Nucleolites (pars), *Agassiz, Desor, Cotteau.*
Echinobrissus (pars), *De Loriol.*
Catopygus (pars), *Agassiz.*

Diagnosis.—Test oblong, more or less depressed, upper surface convex, under surface concave, mouth-opening excentral, nearest the anterior border; peristome surrounded by five rosettes of buccal pores, and separated by five prominent lobes, oral aperture regular, pentagonal, with equal sides and a prominent angle anteriorly. Vent small, situated in a deep groove with perpendicular walls and well-defined outline, extending nearly half way up the dorsal surface of the single inter-ambulacrum, ambulacra narrowly lanceolate, and subpetaloidal; the anterior and posterior pairs, especially the latter, long and flexuous. The pores which compose the zones are sometimes unequal, the external series being more or less elongated in a transverse direction; apical disc small, excentral, and composed of four perforated, and one imperforate genital plates, the right antero-lateral supporting the madreporiform body, which extends into the middle of the disc and forms a prominence there; the five ocular plates are small and angled into the summits of lanceolate ambulacra. The tubercles are very small and set closely together on the upper surface (Pl. LVI, fig. 1 *f*), and larger on the under surface (Pl. LVI, fig. 3 *g*) ; they are all encircled by areal depressions and separated by minute granules.

This group was separated by M. A. d'Orbigny from *Echinobrissus* in consequence of the following characters, which he observed to be constant in all the species :—The large central polypiform madreporiform body; the mouth-opening surrounded by five rosettes of pores, alternating with five well-developed buccal lobes; and the anal sinus circumscribed and contracted.

The species are all special to the Cretaceous formations. M. d'Orbigny described and figured six from the Neocomian and two from the Albian stages, and I now add another form from the Neocomian of the Isle of Wight.

Clypeopygus Fittoni, *Wright*, nov. sp. Pl. LVI, fig. 1—3.

Test oblong, upper surface depressed, highest posteriorly; under surface concave; ambulacra narrow, lanceolate; poriferous zones subpetaloidal above and narrowly biserial on the sides and base; apical disc nearly central; vent-opening at the end of a narrow sinus with vertical walls; mouth-opening at the junction of the anterior with the middle third, peristome surrounded by five prominent lobes and five pairs of subpetaloidal pores, forming together a well-marked rosette.

Dimensions.—No. 1, length $1\frac{1}{10}$ inches, breadth 1 inch; No. 2, length $1\frac{1}{2}$ inches, breadth $1\frac{3}{10}$ inch.

Description.—The outline of the test is oblong, with the sides slightly compressed; the upper surface is convex, flattened at the anterior half, and gradually elevated towards the posterior third, which is the highest part of the test (Pl. LVI, fig. 1 *d*, fig. 3 *e*); from this point it bends abruptly down to the posterior border; Mr. Bones' capital figures in Pl. LVI make this character of the test far more intelligible than the most laboured description could effect.

The ambulacral areas are narrowly lanceolate, the antero- and postero-lateral pairs are long and flexuous, and the single area is short and straight; the poriferous zones (fig. 3 *f*) are slightly subpetaloidal on the dorsal surface (fig. 1 *b*, fig. 3 *b*), and closely biserial on the sides and at the base (fig. 1 *d*, *e*, fig. 1 *c*, fig. 3 *c*); as they approach the peristome, they expand and form five petaloidal expansions around the mouth, which are separated from each other by the five lobes that surround the oral opening (fig. 3 *c*).

The inter-ambulacral areas are largely developed; the antero-lateral are the narrowest, the postero-lateral the widest, and the single area of intermediate width; they are built of large plates bent in the middle, having their surface closely covered with small scrobiculated tubercles arranged in horizontal rows; fig. 1 *f* shows three of these plates and a corresponding portion of the ambulacral area with the poriferous zones, magnified six diameters. The tubercles at the base are larger and wider apart than those on the upper surface, as shown in fig. 3 *g*, where a portion of the base is magnified three diameters; the boss, area, and imperforate tubercle are well seen in this drawing.

The vent opens at the end of a deep sulcus near the middle of the dorsal portion of the single inter-ambulacrum: see figs. 1 *b*, *e*, fig. 3 *b*, *d*; the walls of the sulcus are abruptly perpendicular (fig. 3 *b*, *d*, *e*), and the oval periprocte is seen at the upper portion thereof (fig. 1 *e*, fig. 3 *b*, *d*); the single inter-ambulacrum exceeds in height all the others, for its upper surface is elevated (fig. 1 *a*), and forms the vertex of the test, whilst its under surface is curved downwards and forms a marked prominence in the base (fig. 1 *d*, *e*, fig. 3 *a*, *e*): I have not seen the apical disc well shown in any specimens.

The base is concave, and the mouth-opening occupies a deep depression at the junction of the anterior with the middle third of the base (fig. 3 *c*); the development of the five oral lobes, and the five alternating, petaloidal rosettes impart a remarkable generic character to the only specimen in which this portion of the anatomy of the test is satisfactorily exposed. I have given a figure of this structure, as all the other specimens have the base covered more or less with the coarse grains of the matrix.

Affinities and Differences.—This species resembles *Clypeopygus Cerceleti*, d'Orb., in all the chief points of its anatomy, but differs in the following particulars:—*C. Fittoni* has the test more oblong or subquadrate, and not enlarged posteriorly; the single inter-ambulacrum is more developed, rises higher on the upper surface, and curves lower on the under surface than in d'Orbigny's figure of *C. Cerceleti.*

Locality and Stratigraphical Position.—This rare Urchin was collected from the Lower Greensand of Shanklin, Isle of Wight, by the Rev. T. Wiltshire, F.G.S., and myself. I have dedicated the species to the memory of my old friend Dr. Fitton, F.R.S., whose admirable monograph on the Lower Greensand of the Isle of Wight will long remain a text-book to the explorers of this classical geological region.

Genus—Echinobrissus, *Breynius*, 1732.

Nucleolites,	*Lamarck*, 1801.
—	*Goldfuss*, 1826.
—	*Agassiz*, 1837.
Echinobrissus,	*d'Orbigny*, 1855.
—	*Desor*, 1857.
—	*Cotteau*, 1858.
—	*De Loriol*, 1868.

This natural group is composed of small Urchins which have an oval, oblong, subquadrate, or subcircular form, more or less convex on the upper surface, and slightly concave at the base; the test is obtusely rounded anteriorly, more or less produced, truncated, or lobed posteriorly, and in general is narrower at the anterior than the posterior third; the vent opens into an anal sulcus which in one group extends from the apical disc to the posterior border, and in another is limited to the lower third of the inter-ambulacrum; the periprocte was closed by a series of small anal plates usually absent in fossil forms, but preserved in the only living descendant of the genus.

The base is more or less concave; the mouth-opening is small, pentagonal, excentral, and lodged in an excentral depression; in one group the peristome forms a regular pentagon; in another group it is directed obliquely across the test.

D'Orbigny has separated the latter into a distinct genus under the name *Trematopygus*, all of which are special to the Cretaceous Rocks; and they form a convenient section of the genus, although the characters on which the separation is based are, from my point of view, too slight and evanescent to form a stable generic basis. The apical disc is small, quadrate, and compact; it is composed of four perforated and one imperforate genital plate, the right antero-lateral, supports the madreporiform body; the five oculars are very small and triangular, and are wedged in between the genitals and apices of the lanceolate ambulacra.

The tubercles are small, with perforated summits and depressed areas, and the surface of the plates is covered with microscopic granulations.

The genus *Echinobrissus* was established by Breynius in 1732 in his important memoir 'De Echinis et Echinitis,' and of which I have given a translation at p. 193.

Klein, who published only two years afterwards, did not, unfortunately, preserve the well-defined genera proposed on such good characters by his learned contemporary; and Leske, his commentator, in 1778 placed the *Echinobrissus* of Breynius under the *Spatangus* of Klein. When Lamarck in 1801 proposed the genus *Nucleolites* in the first edition of his great work, he was not aware that the same group of Urchins had been well figured and accurately diagnosed sixty-nine years before by Breynius; but in the second edition of 'Animaux sans Vertèbres' a reference was made to this work for figures of the species. The late Professor Agassiz in dismembering Lamarck's *Nucleolites* unfortunately did not restore Breynius' genus, although, as a rule, Agassiz adhered to the genera of the older naturalists. To the late Professor A. d'Orbigny the honour is due of vindicating the claims of Breynius's work, and which all subsequent Echinologists, Desor, Cotteau, and De Loriol, have rigidly observed.

ECHINOBRISSUS LACUNOSUS, *Goldfuss*,[1] 1829.

NUCLEOLITES LACUNOSUS,		*Goldfuss.* Petref. Germaniæ, pl. xliii, fig. 8, p. 141, 1829.
—	—	*Desmoulins.* Études sur les Échinides, p. 360, 1837.
—	—	*Morris.* Cat. of Brit. Foss., p. 55, 1843.
—	—	*Agassiz* et *Desor.* Cat. raison., p. 97, 1847.
—	—	*Forbes.* Mem. Geol. Survey, Decade i, p. 8, 1849.
ECHINOBRISSUS	—	*d'Orbigny.* Pal. Franç. Ter. Crét., pl. 958, figs. 7—10, 1855.

Diagnosis.—Test ovate, obtuse anteriorly, subquadrate and subtruncate posteriorly, sides subcompressed; upper surface convex, vertex subcentral or supra-anal; ambulacra narrowly lanceolate; anal sulcus deep, short, oblong, and abruptly declined; inter-

[1] No specimen has been found hitherto sufficiently perfect for the purpose of illustration.

ambulacrum subdepressed, recurved; base concave; mouth-opening surrounded by five short petaloid poriferous zones.

Dimensions.—Length seven tenths of an inch; breadth half an inch.

Description.—The test of this species is obtusely rounded before, and subquadrate and truncated behind; the sides are slightly compressed, and the posterior third is the widest part of the ambitus. The upper surface is convex and the under surface concave, and inclined upwards towards the posterior border.

The ambulacral areas are narrowly lanceolate, and the dorsal poriferous zones slightly subpetaloidal on the sides and base; the pores are scarcely visible on the upper surface, but around the mouth they form a five-rayed star of short petaloidal pores, with five oral lobes between them, as in *Clypeopygus.*

The apical disc is small and excentral; four of the ovarial plates are perforated. The surface is covered with scrobiculated tubercles. The mouth is situated at the junction of the anterior with the middle third, and is surrounded with the short rosette of pores already described; the base is concave between the sides, and curves upwards towards the anterior and posterior borders, so that the borders of the postero-lateral inter-ambulacra are convex and prominent at the sides and base, and impart to this Urchin one of its best diagnostic characters. The anal sulcus is short, deep, oblong, and abruptly declined, and occupies the region above the posterior border of the inter-ambulacrum; the vent opens at the extreme end of the sulcus above the middle of the test.

Affinities and Differences.—This Urchin was well figured by Goldfuss, and much resembles *Echinobrissus similis,* d'Orbigny, which appears to be a large variety of *E. lacunosus.* It resembles *E. Roberti,* Gras, from the Upper Neocomian, but is distinguished from that form by the following characters: the anal sulcus is lower, narrower, and nearer the border; the sides are less inflated and more compressed; and the base curves more upwards posteriorly.

Locality and Stratigraphical Position.—This Urchin has been long collected in the Upper Greensand at Longleat, Wilts, and from the Chloritic Marl at Chardstock; the type-specimen was obtained from the Chalk-marl near Essen on the Ruhr, Westphalia.

ECHINOBRISSUS MORRISII, *Forbes,* 1849.

CASSIDULUS LAPIS-CANCRI,		*Morris.*	Cat. Brit. Foss., p. 49, 1843.
NUCLEOLITES MORRISII,		*Forbes.*	Mem. Geol. Surv., decade i, p. 8, 1849.
—	—	*Morris.*	Cat. Brit. Foss., 2 ed., p. 84, 1854.
ECHINOBRISSUS	—	*d'Orbigny.*	Pal. Franç. Ter. Crétacés, pl. 959, 1854.

Diagnosis.—Test oblong, anterior and posterior borders obtusely rounded; sides

compressed, dorsal surface convex; ambulacra lanceolate, subpetaloidal; apical disc excentral and forwards; vertex central; anal sulcus short, deep, and subtriangular; base concave; mouth-opening pentagonal, slightly excentral, and forwards.

Dimensions.—Antero-posterior diameter half an inch; height three tenths of an inch.

Description.—The test is oval and depressed, obtusely rounded before, a little angular, subrostrated, and sloped out behind, and the greatest diameter is at the posterior third. The upper surface is convex; the longitudinal profile shows it to be rounded and depressed at both extremities, with a slight excentral elevation nearer the anterior than the posterior border. The ambulacra are long, lanceolate, and subpetaloidal on the dorsum, narrower at the ambitus, and enlarged in the base; the poriferous zones have the pores unequal, and a little apart above where they form the petals; they are close together and microscopic at the ambitus, and are larger and more numerous near the mouth, where they form a pentagonal star around the peristome. The anal sulcus occupies the lower fourth of the single inter-ambulacrum; it is short, deep, and triangular, and its two lateral walls form prominent carinæ, the sulcus making an excavation in the posterior border; the vent is oval and opens at the summit of the valley.

The apical disc is small, quadrate, with four perforated genital pores; it is slightly excentral and placed a little forwards, and forms the vertex of the test.

The base is very concave, always near the mouth, and greatly undulated at the sides, the single inter-ambulacrum being slightly subrostrated and recurved.

The mouth-opening is excentral, the peristome pentagonal, with one angle directed forwards, and the pores increase in size and number in the ten zones around this aperture.

The scrobiculated tubercles closely cover all the upper surface; beneath they are larger and not so numerous.

Affinities and Differences.—This species, which is very rare in England, was said by the late Professor A. d'Orbigny to resemble *E. Bourguignati*, but to be distinguished from it by having the test much more depressed, subrostrated behind, compressed at the sides, humped at the vertex, and more concave and undulated on the under surface.

Locality and Stratigraphical Position.—According to the late Professor Forbes, who first separated the species from *E. lacunosus*, and gave only an imperfect diagnosis without any figure of the same, this Urchin is found in the Upper Greensand of Warminster and Blackdown, and the type was detected in Professor Tennant's collection. On the Continent it was collected by the late Vicomte d'Archiac from "l'Étage Cénomanien" at Brunswick. Unfortunately the figure of this species was not drawn by my late lamented friend Mr. Bone, as he was waiting to procure a good specimen to draw, and had not obtained one when it was required.

Genus—TREMATOPYGUS, *A. d'Orbigny*, 1855.

NUCLEOLITES (pars), *Agassiz.*
ECHINOBRISSUS (pars), *Desor.*
PHYLLOBRISSUS (pars), *Cotteau.*
— (pars), *De Loriol.*

Form of the test ovate or oblong, a little contracted and rounded before, and more or less enlarged behind.

Upper surface convex, ambitus inflated, posterior inter-ambulacrum slightly rostrated.

Apical disc quadrate, excentral, and nearer the anterior border, composed of four perforate ovarial and one single imperforate plates; the madreporiform body covers the genital elements and forms a prominence in the centre of the disc; the five ocular plates are very small and closely united to the genitals.

The ambulacra are long, lanceolate, and well defined throughout; the poriferous zones are subpetaloidal on the upper surface; the outer rows of the dorsal pores are elongated transversely at the ambitus and base, they are equal, biserial, and microscopic, and around the peristome a few supplementary pairs are present, which are larger and more conspicuous than the others.

The inter-ambulacra are built of large plates bent in the middle, having their surface covered with two or three irregular rows of tubercles, which are perforated, raised on mammelons, and encircled by depressed areas having circles of granules around them, and the inter-tubercular surface is covered with a fine granulation.

The anal sulcus is large, shallow, and limited to the posterior border; the vent is large, oval, or pyriform, and opens near the surface.

The base is flat or slightly concave towards the middle; the mouth-opening is irregularly pentagonal, compressed obliquely from left to right, and from above downwards.

Trematopygus is only a sectional group of the genus *Echinobrissus,* characterised by an oblique compressed peristome, and by the large elongated vent placed in a marginal shallow sulcus.

TREMATOPYGUS FARINGDONENSIS, *Wright*, 1871. Pl. LVII, fig. 1 *a—h*.

TREMATOPYGUS FARINGDONENSIS, *Wright*. In Phillips' Geology of Oxford, p. 434, 1871.

Diagnosis.—Test gibbous, oval, much inflated at the sides and base, narrow in the anterior, and enlarged in the posterior third. Apical disc and vertex excentral and forwards; ambulacra lanceolate, dorsal pores subpetaloid, and sulcus excavated out of the posterior border; vent pyriform, large; base concave, sides undulated by the inflation of the inter-ambulacra; mouth-opening large and oblique, and situated at the junction of the anterior with the middle third.

Dimensions.—*a.* Length one inch and three tenths; height seven tenths of an inch; breadth one inch and two tenths. *b.* Length one inch and five tenths; height seven tenths; breadth one inch and three tenths.

Description.—The test of this rare Urchin has an oval outline, is a little narrower before than behind, and is much inflated at the sides and base. The upper surface is convex with the vertex excentral and forwards, fig. 1 *a* and *b*.

The ambulacra are long, lanceolate, unequal, petaloid; the posterior pair are much longer than the others, and the single area is the shortest and narrowest; at the under surface the ambulacra form depressions, and the inter-ambulacra elevations, so that the base is undulated at the sides and concave in the middle, fig. 1 *c*.

The poriferous zones are well developed at the upper surface and the external rows are slightly elongated, fig. 1 *b;* at the ambitus and base the pores are small and closely biserial, and become larger and more conspicuous around the peristome, fig. 1 *c*.

The apical disc is small and quadrate, fig. 1 *a, b;* the four genital plates are perforated, and the anterior pair set closer together than the posterior pair; the madreporiform body occupies the middle of the disc and forms a prominent button there. The ocular plates are very small and closely united to the other discal elements, see fig. 1 *f*, where the disc is shown magnified six diameters.

The periprocte is pyriform or oval, and acuminated at the upper extremity, fig. 1 *a, b*, and *e*; it is quite supra-marginal; the anal sulcus makes a deep indentation in the posterior border, fig. 1 *b, d, e*, and from its sides two carinæ proceed towards the base, fig. 1 *e*.

The tubercles are prominent and perforated, and raised on bosses surrounded by depressed areas, the margins of which are encircled by granules, and all the inter-tubercular surface is covered with a well-developed granulation, fig. 1 *g;* at the base the tubercles are larger and more spaced out, the mammelons are larger, and the granules surrounding the areas more developed, fig. 1 *h*. In fig. 1 *g* an ambulacral area with the

poriferous zones together with a portion of inter-ambulacra is shown, consisting of three plates magnified six diameters; the arrangement of the tubercles is most accurately given, and their relative size and structure well shown in this drawing.

Affinities and Differences.—This species resembles very much *Trematopygus Campicheanus,* d'Orbigny. Our Urchin is larger and more gibbous, and the anal sulcus wider and more developed; the base likewise is more undulated, from the inflation of the basal portions of the inter-ambulacra; and the arrangement of rows of granules above the pores in the poriferous zones, 'Pal. Française,' pl. 950, fig. 6, is absent in *T. Faringdonensis.* In the absence of specimens with which to compare these nearly allied forms, it is impossible to decide whether they are specifically distinct or only varieties of *T. Olfersii.*

Locality and Stratigraphical Position.—I have collected this Urchin only in the Sponge-gravel beds of Lower Greensand at Coxwell, near Faringdon, Berks. The fine specimen, fig. 1 *a,* was obtained from this locality, and presented to me by my old esteemed friend Thomas Davidson, Esq., F.R.S. I am likewise indebted to E. C. Davy, Esq., F.G.S., Wantage, for several specimens more or less perfect to complete my description of the anatomy of the test of this very rare form. It is worthy of note that the group to which I refer the species all come from beds appertaining to the Middle Neocomian, "*Étage Néocomien moyen,*" a fact of importance helping to determine the age of the Sponge-gravel beds of Berkshire.

Genus—Caratomus, *Agassiz,* 1840.

Small Urchins with an ovoid or circular test rounded before and often rostrated behind; the sides are thick and inflated, the upper surface is convex, and the apical disc excentral and forwards; the base is convex with a slight depression around the mouth-opening, which has neither lobes nor pores.

The vent is infra-marginal and not visible from the upper surface, it is transversely oblong or triangular, and situated in several species in a rostrated development of the single inter-ambulacrum.

The ambulacra are short and subpetaloid, and the zones are formed of simple, equal, non-conjugate pores, disposed in pairs, which are closely approximated at the summit, apart in the middle of the zone, and approximated at the ambitus, Pl. LVII, fig. 2 *b, c;* at the base they are feebly indicated by lines which converge around the mouth-opening.

The tubercles, which are large for so small a test, are scrobiculated, those at the base are the largest, and the surface of the plates likewise is covered with minute granulations.

The apical disc is nearly central, with four perforated ovarials and five small oculars, the spongy body extending into the middle of the disc.

The mouth-opening is nearly central, always obliquely elongated.

This genus belongs essentially to the Cretaceous formations. The Upper Greensand, Craie Chloritée, or Étage Cénomanien, has yielded *C. trigonopygus*, *faba*, *rostratus*, and *orbicularis;* of these the first three are found both in the Anglo-Parisian and in the Pyrenean basins, and the last up to the present time only in the Anglo-Parisian basin.

In the White Chalk, or l'Étage Sénonien are four species—*C. avellanus*, *sulcato-radiatus*, *truncatus*, and *peltiformis*, all of which are found in the Anglo-Parisian basin.

The only specimen discovered in England is *C. rostratus.*

Caratomus rostratus, *Agassiz*, 1840, Pl. LVII, fig. 2 *a—e*.

Caratomus rostratus, *Agassiz.* Catalogus Syst. Ectyp., p. 7, 1840.
— — *Desor.* Monog. des Galerites, p. 38, pl. 5, figs. 1—4, 1842.
— — *Morris.* Cat. of Brit. Foss., p. 49, 1843.
— — *Agassiz* et *Desor.* Cat. Rais., p. 93, Modèle No. 81, 1847.
— — *d'Orbigny.* Prodrom., t. ii, p. 178, Étage 20e, 1847.
— — *Forbes.* In *Morris*' Cat. of Brit. Foss., p. 73, 1854.
— — *d'Orbigny.* Pal. Française, Ter. Crétacés, pl. 941, p. 367, 1855.

Diagnosis.—Test thick, depressed, round, inclining to oblong, obtusely round before, and prolonged into a rostrum behind; apical disc slightly excentral; base convex, pulvinated, depressed near the mouth, which is small, oblique, and excentral; vent triangular, infra-rostral at the lower third of the height; ambulacra narrow and obscured by large scrobiculated tubercles.

Dimensions.—Antero-posterior diameter four tenths of an inch; breadth three tenths of an inch; height two tenths of an inch.

Description.—This little Urchin was first figured and described by M. Desor in his beautiful Monograph on the Galerites and has since been figured by d'Orbigny in the 'Paléontologie Française.' The shell is thick and depressed, longer than wide, very obtuse anteriorly, and ending in a prolonged rostrum posteriorly, which gives it a pyriform aspect.

The ambulacra are narrow and scarcely visible, being obscured by large scrobiculated tubercles; in order to expose the poriferous zones it is often necessary to treat the test with some dilute acid. I have never been fortunate enough to obtain so good a specimen as the one which my late esteemed friend Mr. Bone procured for his beautiful

drawings of this species, and of which he has given details all magnified six diameters. The ambulacra are narrow and subpetaloid and the pores in the zones are small, equal, and non-conjugate. The surface of the test is covered with scrobiculated tubercles, which are large in proportion to the size of the shell; these with the thickness of the test serve to obscure the details of its structure.

The apical disc, which is likewise the vertex, is placed a little before the centre, and is composed of four perforated genital and five ocular plates, and the spongy body projects towards the middle of the disc.

The large triangular vent is situated at the under side of the projecting rostrum, fig. 2 *c, d, e,* and is so completely infra-marginal that the aperture cannot be seen from the upper surface. The great development of the intra-ambulacrum which produces the rostrum forms one of the most marked characters of this species, fig. 2 *c,* and serves to distinguish it from the congeners.

The base is convex and pulvinate; it is a little depressed near the middle, where the oblique mouth-opening is situated, fig. 2 *c;* the lines of zone-pores are here visible, and the scrobiculated tubercles are even larger than on the upper surface.

Affinities and Differences.—This species resembles *C. trigonopygus,* but is distinguished from it by its long recurved rostrum, fig. 2 *c.* The shell is likewise more inflated and the base more convex.

Locality and Stratigraphical Position.—This species is found only in the Upper Greensand near Warminster, Wilts. In France it is likewise special to "l'Étage Cénomanien," or the "Craie Chloritée," from whence it has been collected at Havre, Seine-Inférieure, at Fourras, Charente-Inférieure, and at Vaches-Noires, Calvados.

Family 10—Echinolampidæ, *Wright,* 1856.

Test thin, oval, oblong, elevated, or subdiscoidal; ambulacral areas large, petaloidal; poriferous zones wide, pores distant, united by sutures, and extending nearly to the margin.

Mouth-opening small, subcentral; peristome surrounded by five prominent lobes, and always by a well-developed pentaphylloid floscelle.

Vent oval transversely and infra-marginal.

Apical disc very small, excentral, and composed of four perforated genital and one imperforate plate, with five minute oculars wedged into the circumference of the disc.

Plates of the upper surface covered with several rows of numerous small, closely set tubercles encircled by sunken areolas.

A few species are now living in warm seas; the greatest number are extinct, and

found in the Oolitic, Cretaceous, and Tertiary rocks, where they form important leading fossils of the strata which they characterise.

I include the following genera in this Family:

ECHINOLAMPAS, *Gray.*	ECHINANTHUS, *Breynius.*
PYGURUS, *d'Orbigny.*	CONOCLYPUS, *Agassiz.*
FAUJASIA, *d'Orbigny.*	PYGAULUS, *Agassiz.*

Genus—PYGURUS, *d'Orbigny,* 1855.

ECHINANTHITES,	*Leske,* 1778.
CLYPEASTER (pars),	*Lamarck,* 1801.
ECHINOLAMPAS (pars),	*Agassiz,* 1836.
PYGURUS (pars),	*Agassiz,* 1840.
—	*d'Orbigny,* 1855.
—	*Desor,* 1858.
—	*De Loriol,* 1873.

The genus *Pygurus,* as now limited, is composed of large, discoidal, or clypeiform Urchins, in which the test in general is more or less enlarged at the sides, and rostrated posteriorly; its upper surface is usually depressed, and rarely elevated. The ambulacral areas and poriferous zones in the upper surface form petaloidal expansions, which have an elegant figure, being in general contracted at the border, enlarged in the middle, and attenuated at the apex. The anterior single area is narrower than the antero- and postero-lateral areas; the summit is in general central, or slightly excentral, the inclination being always forwards. The base is concave and much undulated, the wide basal interambulacra swell into prominent cushions, and the narrow ambulacra form contracted valleys between them. The mouth-opening is pentagonal, and always excentral; the peristome is surrounded by five prominent lobes, with which five expanded ambulacral petals alternate; in the poriferous zones near the mouth the pores are closely crowded in triple oblique ranks; these perforated petals form an oral rosette or a penta-phylloid floscelle of considerable dimensions (Pl. LVIII, fig. 1 *c*).

The vent is infra-marginal; it is in general oval, and surrounded by a distinct area, which occupies the rostrated portion of the single interambulacrum; the long diameter of the opening in general corresponds with the longitudinal axis of the test, although it is sometimes transverse (Pl. LVIII, fig. 1 *c*).

The apical disc is very small, and occupies the summit; it is composed of two pairs of

narrow, perforated, and a single rudimentary imperforate, ovarial plate; five minute ocular plates, are interposed between the ovarials (Pl. LVIII, fig. 1 *h*).

The small madreporiform body is attached to the surface of the right anterior ovarial, and forms thereon a spongy eminence, which extends over the other discal elements.

The tubercles are very small on the upper surface, and larger at the base; they are surrounded by sunken areolas, and have their summits perforated; the intertubercular space is covered with close-set miliary granules (Pl. LVIII, fig. 1 *g*).

The genus *Pygurus* first appears in the Lower Oolites, and its species are likewise found in the Inferior Oolite, Fuller's Earth, Great Oolite, Cornbrash, Kelloway Rock, Coralline, and Portland Oolite.

In the Cretaceous formations the species *Pygurus rostratus, P. Gillieroni, P. Buchii,* characterise the Lower Neocomian or Valangian; *Pygurus Montmolini* and *P. Salevensis* are found in the Middle Neocomian; *Pygurus productus* comes from the Urgonian; *Pygurus Ricordeanus* from the Gault; *Pygurus Lampas* from the Upper Greensand or Cenomanian. Of the eight Cretaceous species one is found in the English Upper Greensand, where it is so rare that I know only of two specimens, and one of these is preserved in the British Museum.

Pygurus Lampas, *De la Beche*, 1819, Pl. LVIII, figs. 1*a*—1*h*.

Clypeaster oviformis,	*Lamarck.*	Anim. sans Vertèbres, t. iii, p. 15, 1816.
Echinolampas Lampas,	*De la Beche.*	Geol. Trans., 2nd ser., p. 112, t. iii, fig. 3, 1819.
Pygurus trilobus,	*Agassiz.*	Cat. Syst. Ecty., p. 5, 1840.
— —	*Agassiz* and *Desor.*	Cat. rais., p. 103, Modèle No. 39, 1847.
— —	*d'Orbigny.*	Prodrome, t. ii, p. 178, Étage 20, 1847.
— oviformis,	*d'Orbigny.*	Pal. Française, t. 919, tom. vii, p. 311, 1855.
— Lampas,	*Desor.*	Synopsis Echinides foss., p. 311, 1858.

Diagnosis.—Test high, very convex above and concave beneath, much longer than wide, largely rostrated, and abruptly truncated behind; ambulacra lanceolate, poriferous zones subpetaloidal, apical disc and vertex excentral; base very concave and much undulated; mouth excentral; peristome surrounded by a pentapetaloid floscelle of complicated structure; interambulacrum much developed, recurved, and truncated; vent transverse and infra-marginal.

Dimensions.—This very rare British Urchin was first noticed by my old esteemed friend Sir Henry De la Beche, F.R.S., who collected it from the Upper Greensand near Lyme Regis, and figured it in the 'Transactions of the Geological Society,' depositing the specimen

in the British Museum. Sir Henry called it *Lampas*, from its resemblance to an ancient lamp when held with the base uppermost. Lamarck, 1816, described a *Clypeaster* as *C. oviformis*, from the South Sea, collected by Peron and le Sueur, and referred "la variété que se trouve fossile dans les vignes aux environs du Mans" to the same species. From the angular character which the posterior half of the test exhibits Agassiz called it *trilobus*. D'Orbigny, finding that Lamarck had noticed the fossil species from Mans as a variety of *C. oviformis*, has given this name to the fossil, which is quite distinct from the living form. I have, therefore, followed my friend Professor Desor, and retained Sir Henry De la Beche's most appropriate name.

The test is oval or oblong, obtusely rounded before, hollowed out on the sides, and prolonged into an abruptly truncated rostrum behind; it is very convex, and inflated on the upper surface, its profile forming a regular curve, which is a little more depressed behind the vertex than before (fig. 1 *a*). The ambitus is very angular (fig. 1 *a*, *b*) in its posterior half, and the two lateral and one posterior lobe gives value to the name *trilobus* which was proposed for it. The single inter-ambulacrum is much prolonged, and on it two carinæ are developed, which proceed from the apical disc to the sides of the truncated border (fig. 1 *b*, *c*), and impart a still more angular appearance to the test.

The ambulacra are largely petaloid on the upper surface (fig. 1 *b*). They are contracted at the ambitus (fig. 1 *d*, *e*), and are again largely developed and petaloidal at the base (fig. 1 *c*).

The poriferous zones are well developed and visible throughout in the petaloidal portion on the dorsum; the pores in the external row are elongated, and in the internal row round; at the ambitus they are remote and microscopic, and in the base they again become largely petaloidal, where they surround the mouth; the petals here are distinguished by their elegant forms and complicated structure; the pores are increased in number, and set in oblique pairs on the sides of the petals, and in the centre of each is a longitudinal enlargement like the stem of a leaf (fig. 1 *c*). This remarkable structure is shown magnified two diameters.

The large plates on the upper surface have several rows of small tubercles, which become larger and less numerous at the base (fig. 1 *g*); besides these a fine close-set granulation covers the surface of all the plates.

The apical disc is very small, so that the lanceolate ambulacra meet close together at the vertex, which is slightly excentral; there are four perforated genital plates, with a small spongy body in the centre (fig. 1 *h*).

The vent is large, transversely oval, and opens near the border of the infra-marginal portion of the rostrum (fig. 1 *c*).

Affinities and Differences.—This fine Urchin is distinguished from its congeners by its elevated upper surface, angular ambitus, prolonged rostrum and hollowed-out sides, by its rostral carinæ, and the remarkable pentapetaloid arrangement of the pores around the peristome.

Locality and Stratigraphical Position.—It was collected from the Upper Greensand near Lyme Regis, where it appears to be very rare, as I have seen only one other English example in addition to Sir Henry De la Beche's gift to the British Museum. In France it is found not unfrequently in the Micaceous Sandstone, l'étage Cénomanien of Mans, Sarthe, and in the Grès Calcarifère (Cénomanien), of Fouras, Charente-Inférieure.

Family 11.—Clypeasteridæ, *Wright*, 1856. (Not yet found in British Cretaceous strata.)

Family 12.—Spatangidæ, *d'Orbigny*, 1853.

The general outline of the urchins of this family is oval, oblong, or cordiform, and they satisfactorily exhibit the bilateral symmetry of the Echinidæ. The mouth is anterior, bilabiate, and edentulous. The anal opening is posterior and supramarginal, and closed by a complicated series of small periproctal plates. The ambulacral areas are united at the summit of the test. The anterior single ambulacrum has a different structure from the antero- and postero-lateral pairs, and is lodged in a depression of the test, which extends to the anterior border and forms the anteal sulcus; the test is extremely thin, and covered with small perforated tubercles, which support hair-like spines; besides these there are some larger crenulated and perforated tubercles, which support large spines. There are two or four genital pores, which are sometimes placed close together, but in other genera are apart. The eye-plates are five in number, and placed in a pentagonal form at the apices of the ambulacra around the genital plates. We observe on the surface of the test of some Spatangidæ certain delicate lines called *fascioles*, having a smoother appearance than the tubercular surface of the test; they are furrows which are strewed with microscopic tubercles destined to carry very delicate spines which, when seen under the microscope, appear to have a structure similar to the Pedicellariæ. The fascioles have a different disposition in each genus, and afford a good generic character in giving definitions of the same; when the fasciole surrounds the ambulacral petals like an undulating groove, as in *Hemiaster*, *Schizaster*, &c., it is said to be peripetalous; when it surrounds the single ambulacrum, as in *Amphidetus*, it is internal; when it extends along the sides, as in *Schizaster*, it is lateral; when it encircles the circumference of the test, as in *Pericosmus*, it is marginal; when it is limited to the base of the anal opening it is

subanal. We find sometimes in the same genus more fascioles than one; thus the subanal and peripetal are frequently associated together.

This family contains many genera, none of which are found in rocks older than the Cretaceous formations; the species increase in number in the Tertiary beds, and attain their greatest development in our present seas. In the Cretaceous rocks we find the extinct genera

HEMIASTER, *Desor.*	ENALLASTER, *d'Orbigny.*
EPIASTER, *d'Orbigny.*	HETERASTER, *d'Orbigny.*
MICRASTER, *d'Orbigny.*	ECHINOSPATAGUS, *Breynius.*

The new genus *Paleopneustes,* Al. Agassiz, proposed for a species brought from Barbadoes by the Hassler expedition, appears to furnish an interesting link between the ECHINOCORIDÆ and SPATANGIDÆ. In its general form it resembles *Echinocorys vulgaris,* its anteal sulcus is rudimentary, and it has structural affinities with the anterior single area of that Urchin. The other ambulacra are subpetaloidal; and the peristome bilabiate with well-developed lips.

Genus—HEMIASTER, *Desor,* 1847.

Urchins with a short, elevated, inflated, or cordiform test. The ambulacral summit in general excentral and posterior. The pairs of ambulacra petaloidal, unequal in length, and lodged in depressions of the surface; poriferous zones large and equal in the same ambulacra, the pores elongated and placed close together. The single ambulacrum lodged in a long, shallow, anteal sulcus; the poriferous zones are very narrow and composed of small round pores, sparsely disposed in oblique, widely separate, simple pairs.

The fasciole single, peripetalous, and circumscribing the ambulacra.

The apical disc small and compact, four perforated genital plates, and five very small oculars.

Peristome bilabiate, very excentral, opening at the anterior fourth part of the base.

Periprocte opening high up on the posterior border, which is in general flat, and obliquely truncated.

Hemiaster differs from *Micraster* in having a single peripetalous fasciole and no anal fasciole; the test likewise is in general shorter, more inflated, and the posterior pair of ambulacra are much shorter than the anterior pair. *Hemiaster* differs from *Periaster* in having only a peripetalous fasciole, the latter having both peripetalous and lateral fascioles.

Hemiaster Morrisii, *Forbes*, 1854. Pl. LXI, fig. *a—k*.

Spatangus prunella,	*Mantell.* Geology of Sussex, pl. xvii, figs. 22, 23, 1822.
Hemiaster —	*Desor.* (pars) Cat. raisonée, p. 122, 1847.
Echinospatangus cordiformis,	*Mantell* (pars). Geol. Sussex, p. 108, 1822.
Spatangus complanatus,	*Mantell.* Medals, p. 355.
Hemiaster punctatus,	*d'Orbigny.* Pal. Franc. Ter. Cret., pl. 886, 1854.
— Morrisii,	*Forbes.* Morris, Cat. Brit. Foss., 2nd ed., p. 81, 1854.
— —	*Woodward.* Mem. Geol. Surv., decade v, pl. ix, 1856.

Diagnosis.—Test oval, polygonal, or cordiform, inflated, obtusely rounded before and obliquely truncated behind, sides nodulated; ambulacra straight, narrow, moderately depressed, anterior pair twice as long as posterior, anteal sulcus short, shallow, dorsal; apical disc excentral backwards; vertex near posterior border, which is flat and obliquely truncated; periprocte oval, supra-marginal; base convex, with a slight depression near the mouth, which is bilabiate and opens near the border; fasciole narrow, distinct, closely surrounding the petals.

Dimensions.—Antero-posterior diameter one inch and six tenths; breadth one inch and five tenths; height one inch.

Description.—This Urchin has been long known to collectors of Cretaceous fossils by many incorrect names. I have now figured it with ample anatomical details for the first time, which for the future will make it impossible to mistake it for any other.

The outline is oval, slightly polygonal, or inclining to a cordate shape; the anteal sulcus is broad and obscure, and impresses slightly the anterior border, which is obtusely rounded and sometimes flattened; the posterior border is obliquely and flatly truncated, and slopes at an angle of 70°; sometimes this border becomes slightly concave in large shells, and it is conspicuously so in three specimens in my collection.

The ambulacral petals are small and moderately depressed, the anterior incline 45°; are nearly twice as long as the posterior pair (fig. 1 *a*); the poriferous zones are narrow, and the pores form oblique transverse slits in them; the single area is about same length as the anterior, and is lodged in the anteal sulcus; there are from twelve to fourteen pairs of pores in each zone, with a prominent granule between each of the pores forming a pair (fig. 1 *a*); the anteal sulcus widens out and disappears at the anterior border.

The inter-ambulacral areas present a remarkable nodulated appearance in this species; in each area there are two rows of these elevations; those at the sides are seen in fig. 1 *a*, *c*; in the front in fig. 1 *e*; and the back fig. 1 *d*; in fig. 1 *h* the appearance

these nodules present is admirably shown in three inter-ambulacral plates taken from the ambitus and magnified three diameters.

The peripetalous fasciole is very well defined in this species; it passes straight from point to point with scarcely any curvature, and forms a bold line among the numerous tubercles; fig. 1 *g* shows this structure.

The tubercles are small, very numerous, and set irregularly on the plates; they are all perforated, and raised on bosses surrounded by well-defined areolas; fig. 1 *i* shows the tubercles on the upper surface, and fig. 1 *k* those on the under surface, where the larger tubercles have the bosses crenulated; besides the tubercles the entire surface of the plates is closely covered with miliary granules.

The apical disc is small and excentral, the four genital plates are perforated, and the antero-lateral carries the spongy body (fig. 1 *f*); the five ocular plates are very small, as shown in fig. 1 *f*.

The oval periprocte occupies the upper third of the oblique posterior border (fig. 1 *d*), and the vertex is seen rising above it all, as shown in fig. 1 *c*, *d*).

The base is convex transversely behind the mouth (fig. 1 *b*, *c*), and flat before that aperture. The basal portions of the ambulacral areas, especially the postero-lateral pair, which first descend backwards towards the ambitus, bend round the border forming an obtuse angle there, and make a sinuous course to the mouth. The anterior pair and the single area have a more direct course; the basal portions of the postero-laterals are destitute of tubercles and granules (fig. 1 *b*).

The mouth-opening is situated at the anterior fourth of the base; it is transversely arched and bilabiate, the lower lip being the most prominent, and the peristome is surrounded by a narrow calcareous band.

The tubercles on the basal portion of the inter-ambulacrum have a remarkable arrangement. They form a series of curved rows that radiate from a central nodule near the posterior border and from a kind of fan-shaped tubercular sculpture between the two smooth winding paths formed by the sinuous ambulacra (fig. *b*). The tubercles on the other portions of the inter-ambulacra have a much less regular arrangement.

Affinities and Differences.—This species resembles *H. prunella,* Desor, with which it has been confounded; it differs from that species, however, in being much larger, less globular and inflated, having the posterior border obliquely truncated, the dorsum much more inclined, and having the tubercles smaller and more numerous, and the inter-ambulacra nodulated around the sides.

Locality and Stratigraphical Position.—This species is found only in the Grey Chalk near Folkestone, the Lower Chalk at Hamsey, Sussex, and in the Grey Chalk of Ventnor, Isle of Wight.

Hemiaster Bailyi, *Forbes.* Pl. LX, fig. 2.

Echinospatangus, *Mantell.* Geology of Sussex, p. 86, 1822.
Holaster argillaceus, *Morris* (pars.), Catalogue Brit. Foss., 1st ed., p. 54, 1843.
Hemiaster Bailyi, *Forbes.* Morris, Catalogue, 2nd ed., p. 81, 1854.
— — *Woodward.* Mem. Geol. Surv., decade v, 1856.

The specimen figured in this plate belongs to the Museum of the Royal School of Mines, and is so much crushed and its characters defaced that I am unable to give a correct diagnosis of the species, and now figure it as the authentic example of my late friend's species. The outline figure and general contour of the test resemble *Echinospatagus Murchisonianus.* "The peripetalous fasciole is narrow, distinct, and simple in contour, passing from end to end of the ambulacral petals and only slightly contracted at the sides. The surface of the Echinidæ from the Gault is in general rough with nodular concretions of iron pyrites formed upon the tubercles. So many of the Blackdown fossils are identical with species of the Folkestone Gault that we have felt considerable hesitation in admitting as specific a character which may by any possibility be due to the mineral condition of the specimens."—Woodward.

Locality and Stratigraphical Position.—Collected from the Gault at Folkestone; the type-specimen I have figured is contained in the Museum of the Royal School of Mines.

Hemiaster asterias, *Forbes.* Pl. LX, fig. 3.

Hemiaster asterias, *Forbes.* In Morris, Catalogue, 2nd ed., p. 81, 1854.
— — *Woodward,* Mem. Geol. Surv., decade v, 1856.

The type-specimen I have figured is not sufficiently well preserved to enable me to form a diagnosis of the species. The vertex appears to have been more prominent and removed more posteriorly than in *H. Bailyi,* and the dorsal ambulacra are likewise rough and narrower in proportion than in that species.

Locality and Stratigraphical Position.—Collected from the Gault at Folkestone, where it is rare. The type-specimen I have figured belongs to the Museum of the Royal School of Mines, Jermyn Street.

PLATE LIII.

ECHINOCONUS ABBREVIATUS, *Desor.*

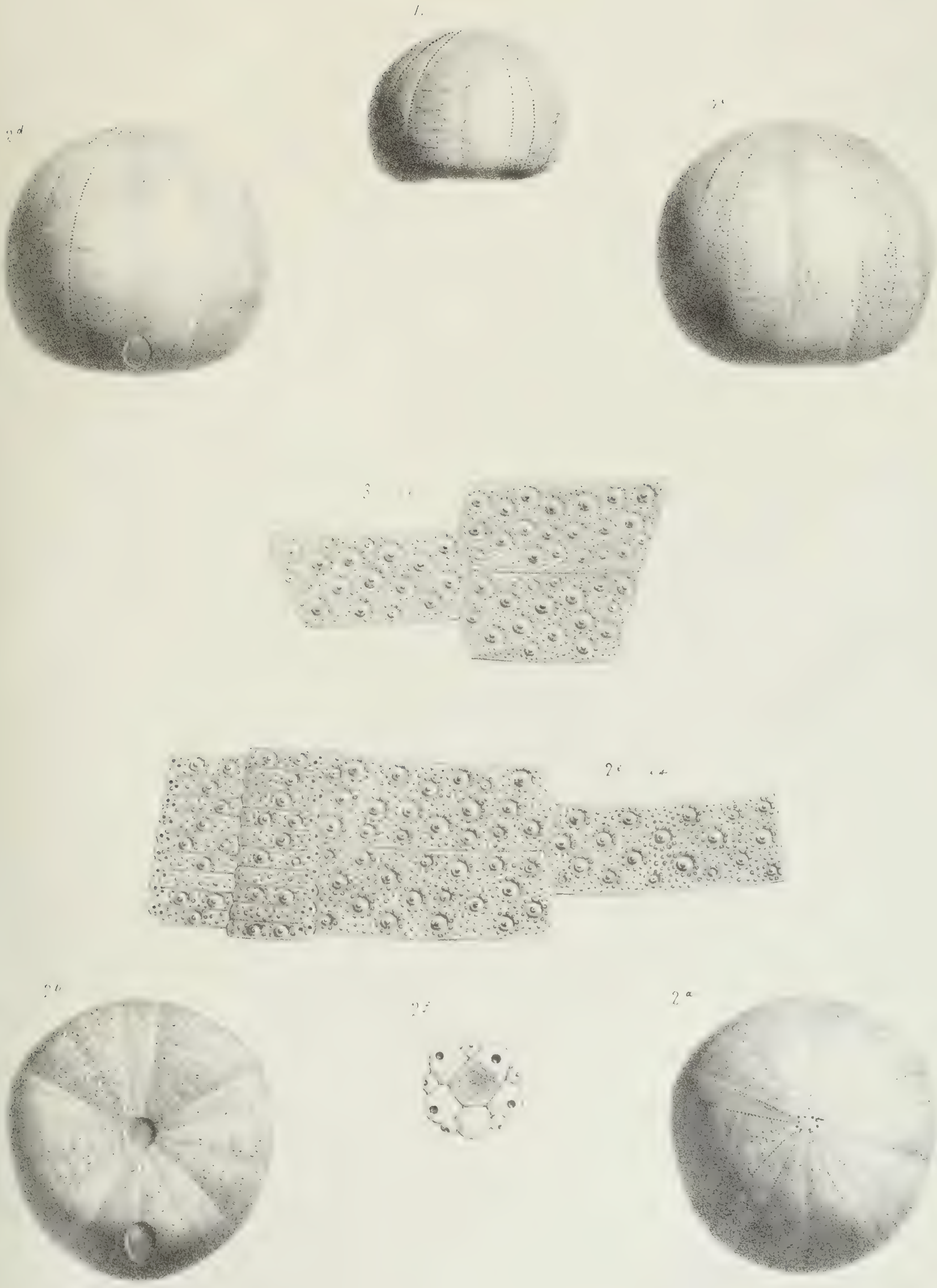
From the Upper Chalk.

Fig. 1. Large test, lateral view, natural size. My collection. (P. 226.)

ECHINOCONUS SUBROTUNDUS, *Mantell.*

From the Lower Chalk.

Fig. 2 *a.* Upper surface, natural size. My collection. (P. 219.)
b. Under do. do.
c. Lateral view do.
d. Posterior do. do.
e. Ambulacral and inter-ambulacral plates and poriferous zones, magnified four diameters.
f. Apical disc, highly magnified.
3. Inter-ambulacral basal plates, magnified six diameters.



C R Bone del et lith

PLATE LIV.

Pyrina lævis, *Agassiz*.

From the Upper Greensand.

Fig. 1 *a*. Test, upper surface, natural size. My collection. (P. 238.)
b. Do. do. magnified two diameters.
c. Do. under surface do. do.
d. Do. lateral view do. do.
e. Do. posterior view do. do.

Pyrina Desmoulinsii, *D'Archiac*.

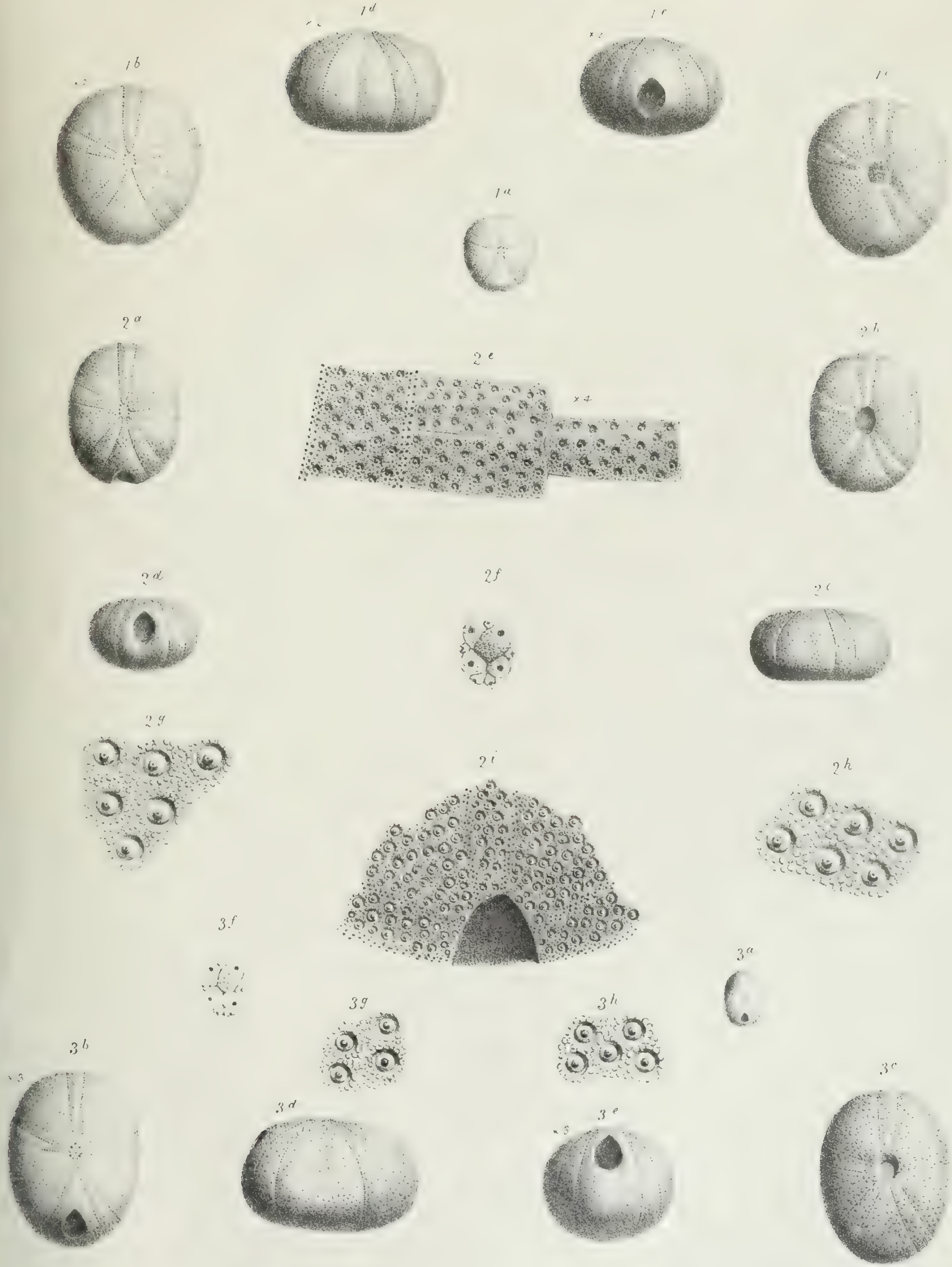
From the Chloritic Marl.

Fig. 2 *a*. Upper surface, natural size My collection. (P. 236.)
b. Under do. do.
c. Lateral view do.
d. Posterior do. do.
e. Ambulacral and inter-ambulacral plates and poriferous zones, magnified four diameters.
f. Apical disc, highly magnified.
g, *h*, *i*. Various forms of basal tubercles, highly magnified.

Pyrina ovulum, *Lamarck*.

From the Upper Greensand.

Fig. 3 *a*. Test, upper surface, natural size. Royal School of Mines. (P. 237.)
b. Do. do. magnified three diameters.
c. Do. under surface do. do.
d. Do. lateral view do. do.
e. Do. posterior do. do. do.
f. Apical disc, highly magnified.
g. Plates, tubercles, and granules, highly magnified.
h. Do. do. do. do.



C. R. Bone del et lith.

M & N. Hanhart imp.

PLATE LV.

Catopygus Vectensis, *Wright*, nov. sp.

Lower Greensand.

Fig. 1 *a.* Test, natural size, upper surface. Rev. T. Wiltshire, F.G.S., and my collection. (P. 245.)

b. Do. magnified two diameters.

c. Do. lateral view, magnified two diameters.

d. Do. posterior do. do. do.

Catopygus columbarius, *Lamarck.*

From the Upper Greensand.

Fig. 2 *a.* Test, upper surface, natural size. My collection. (P. 241.)

b. Do. do. magnified two diameters.

c. Do. under surface do. do.

d. Do. lateral view do. do.

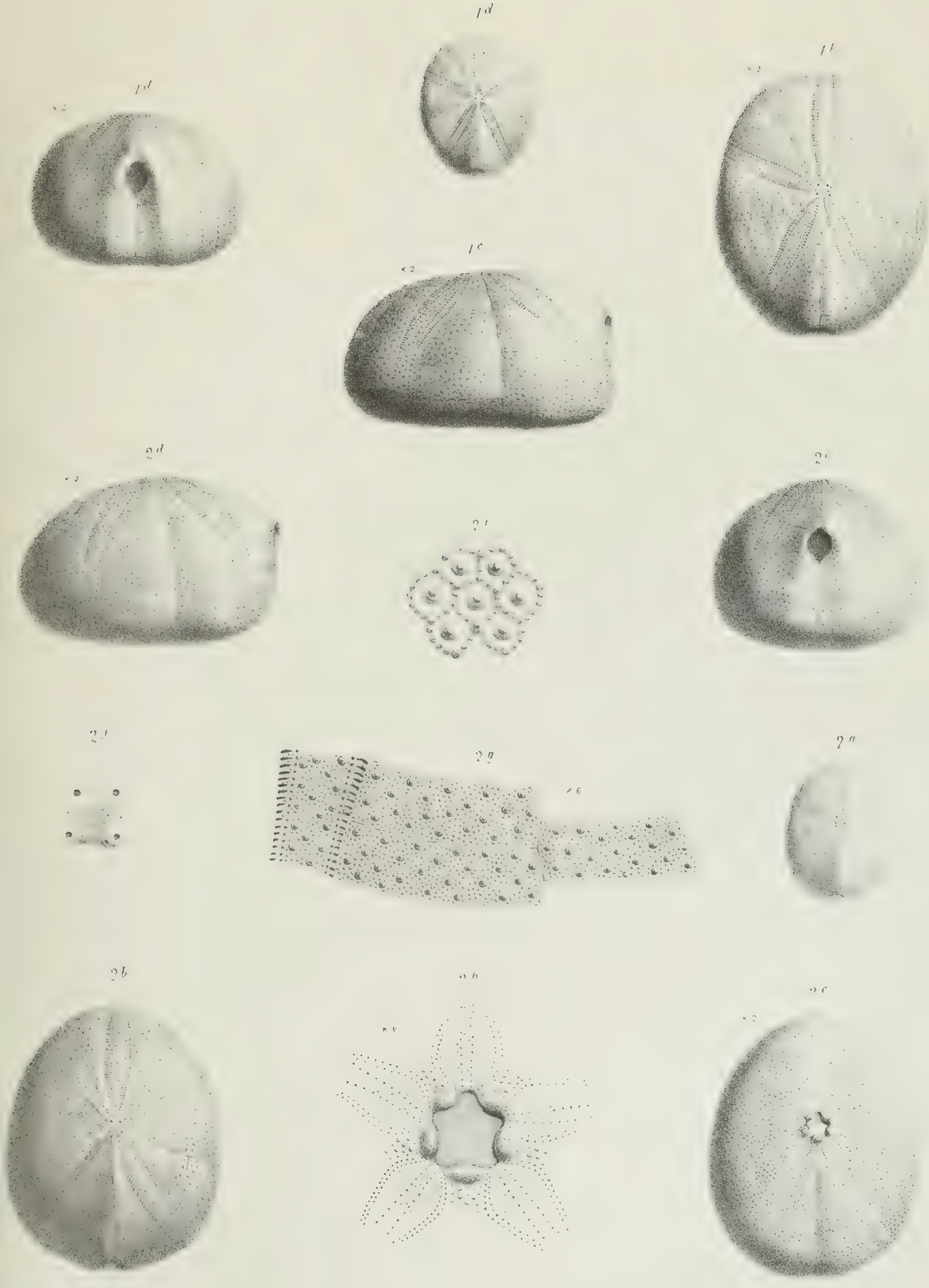
e. Do. posterior do. do. do.

f. Apical disc, largely magnified.

g. Ambulacral and inter-ambulacral plates, with poriferous zones, magnified six diameters.

h. Mouth, oral lobes, and peristomal rosette around the opening, magnified six diameters.

i. Tubercles from the base highly magnified.



C R Bone del et lith.

M & N Hanhart imp

PLATE LVI.

CLYPEOPYGUS FITTONI, *Wright*, nov. sp.

From the Lower Greensand.

Fig. 1 *a*. Length of the test, natural size. Rev. T. Wiltshire, and my collection. (P. 247.)

b. Upper surface, magnified two diameters.

c. Under do. do. do.

d. Lateral view do. do.

e. Posterior do. do. do.

f. Ambulacral plates and poriferous zones, magnified six times.

2 *a*. Test of another specimen, natural size.

3 *a*. Length of do. do.

b. Upper surface, magnified two diameters.

c. Under do. do. do.

d. Posterior do. do. do.

e. Lateral do. do. do.

f. Ambulacral plates and zones, magnified.

g. Basal tubercles of this form are found near the peristome.

Fig. 4. Another test, natural size.

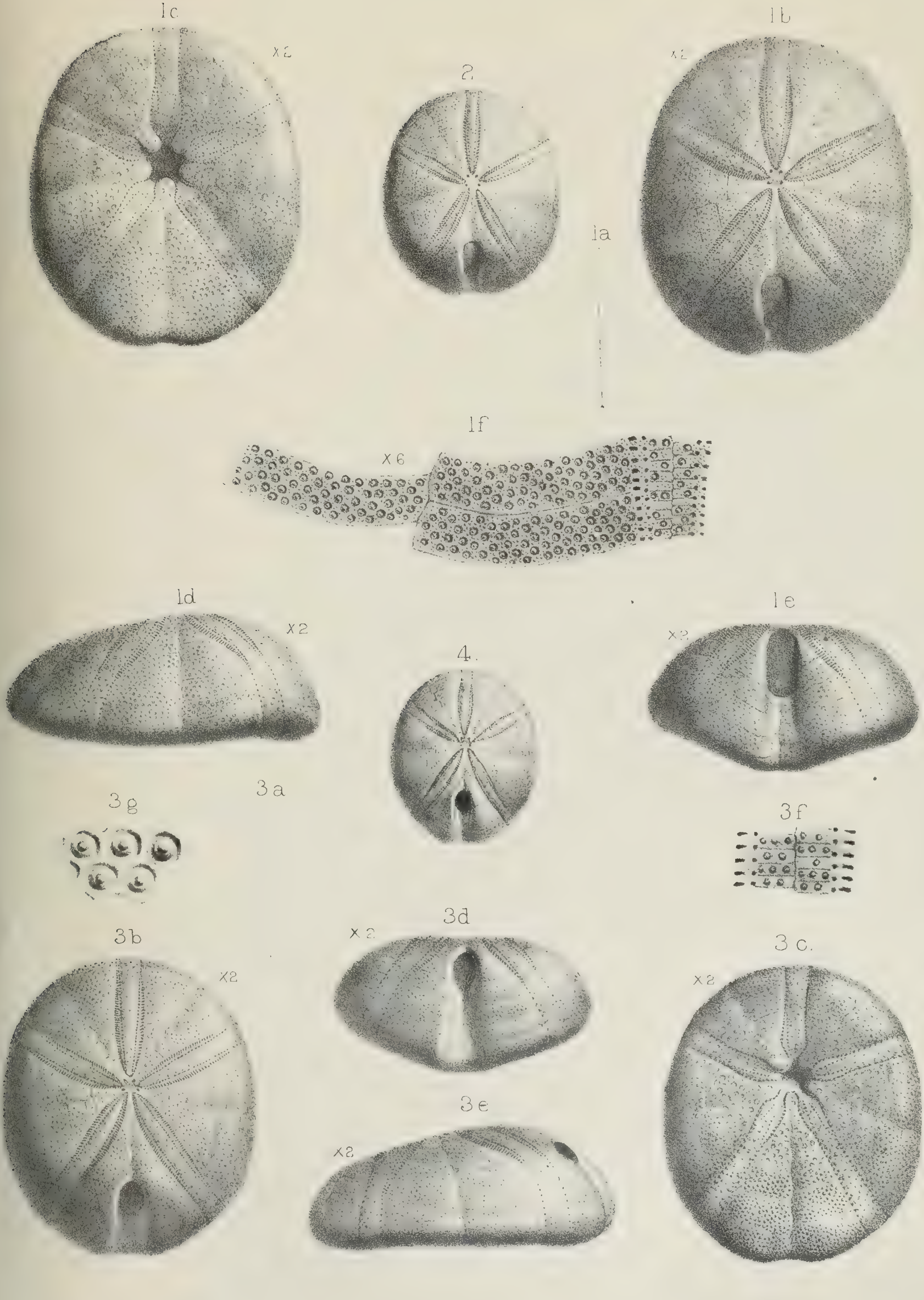

1c
×2
2
1b
×2
1a
1f
×6
1d
×2
4.
1e
×2
3a
3g
3f
3d
×2
3b
×2
3c.
×2
3e
×2

PLATE LVII.

TREMATOPYGUS FARINGDONENSIS, *Wright.*

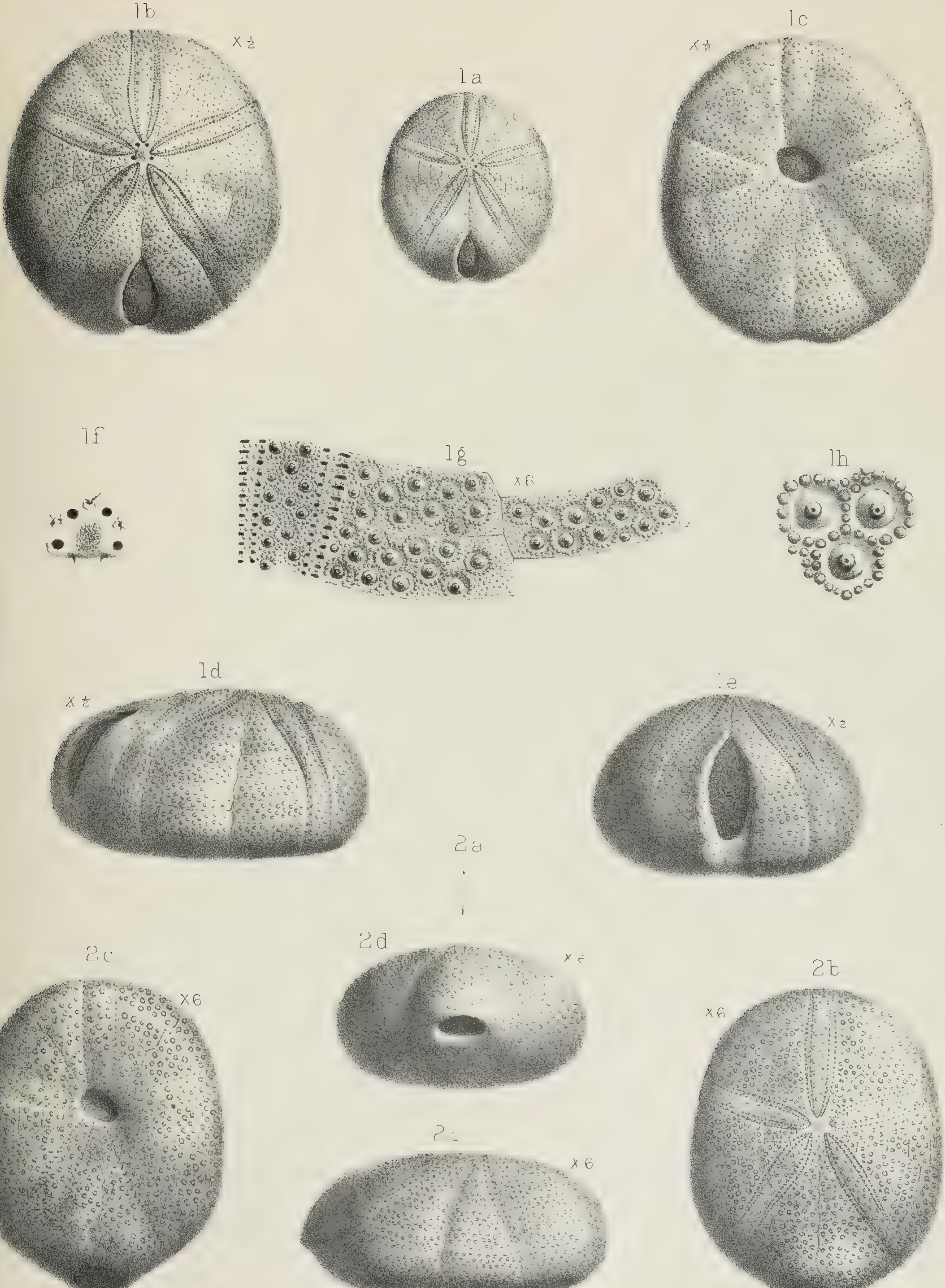
From the Lower Greensand.

Fig. 1 *a*. Test, upper surface, natural size. My collection. (P. 253.)
b. Do. do. magnified one and a half times.
c. Do. do. do. do.
d. Do. lateral view do. one half.
e. Do. posterior do. do. do.
f. Apical disc, magnified.
g. Ambulacral and inter-ambulacral plates and poriferous zones, magnified six times.
h. Basal tubercles, showing structural details.

CARATOMUS ROSTRATUS, *Agassiz.*

From the Upper Greensand.

Fig. 2 *a*. Vertical line, showing natural size. (P. 255.)
b. Upper surface, magnified six diameters.
c. Under do. do. do.
d. Posterior do. do. do.
e. Lateral view do. do.



el et Lith

F Waller Lith 18 Hatton Garden

PLATE LVIII.

PYGURUS LAMPAS, *De la Beche.*

From the Upper Greensand.

Fig. 1 *a.* Test, upper surface, natural size. British Museum. (P. 258.)

b. Do. do. magnified one and a half times.

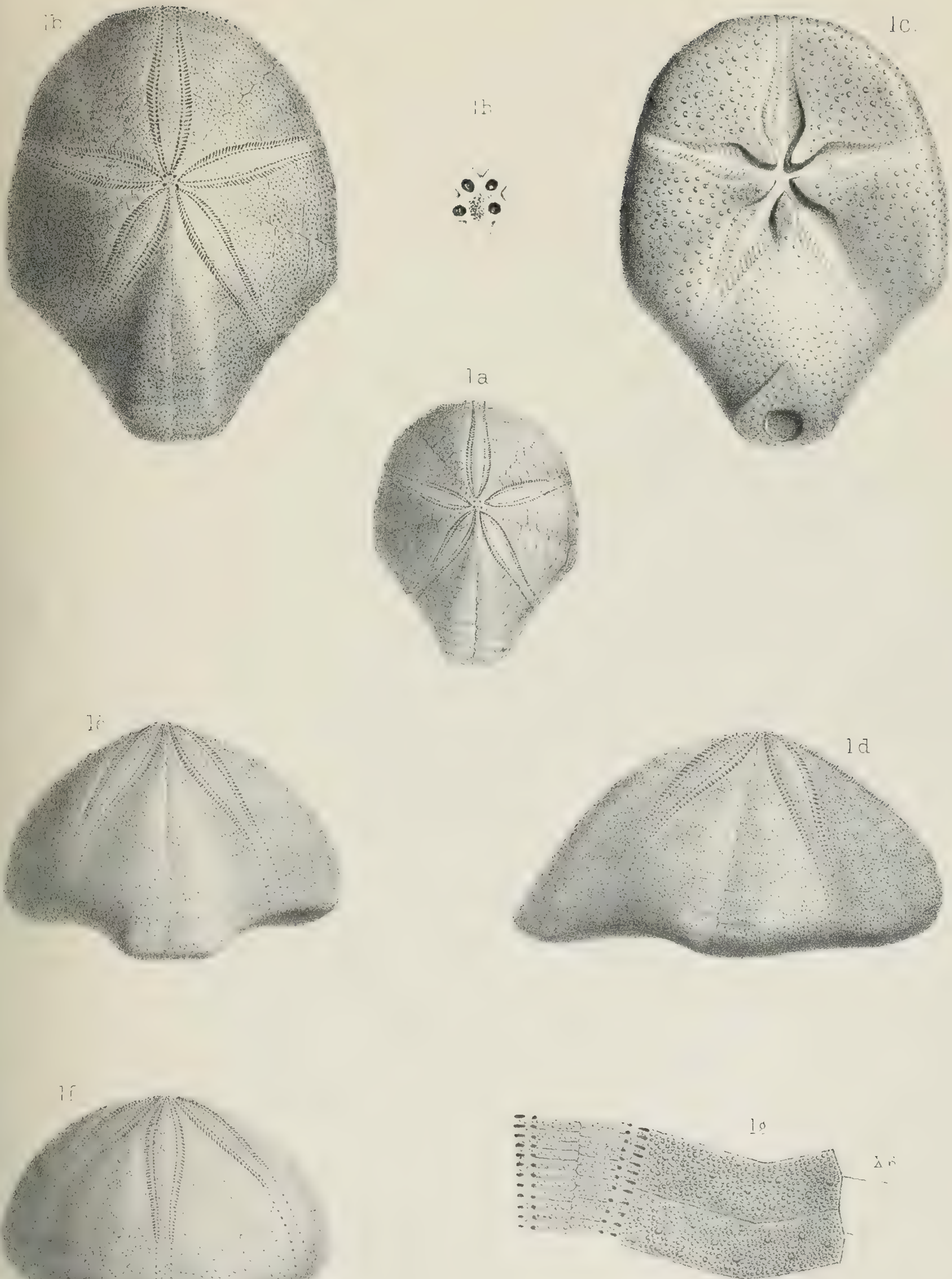
c. Do. under surface do. do.

d. Do. lateral view do. do.

e. Do. posterior do. do. do.

f. Do. anterior view of the front of the test, magnified one and a half times.

g. Ambulacral and inter-ambulacral plates, with poriferous zones, magnified six times.



Del et Lith

F Waller lith 18 Hatton Garden

PLATE LIX.

EPIASTER DE LORIOLII, *Wright.*

From the Upper Greensand.

Fig. 1 *a.* Test, upper surface, natural size. My collection. (P. 265.)

b. Do. under do. do.

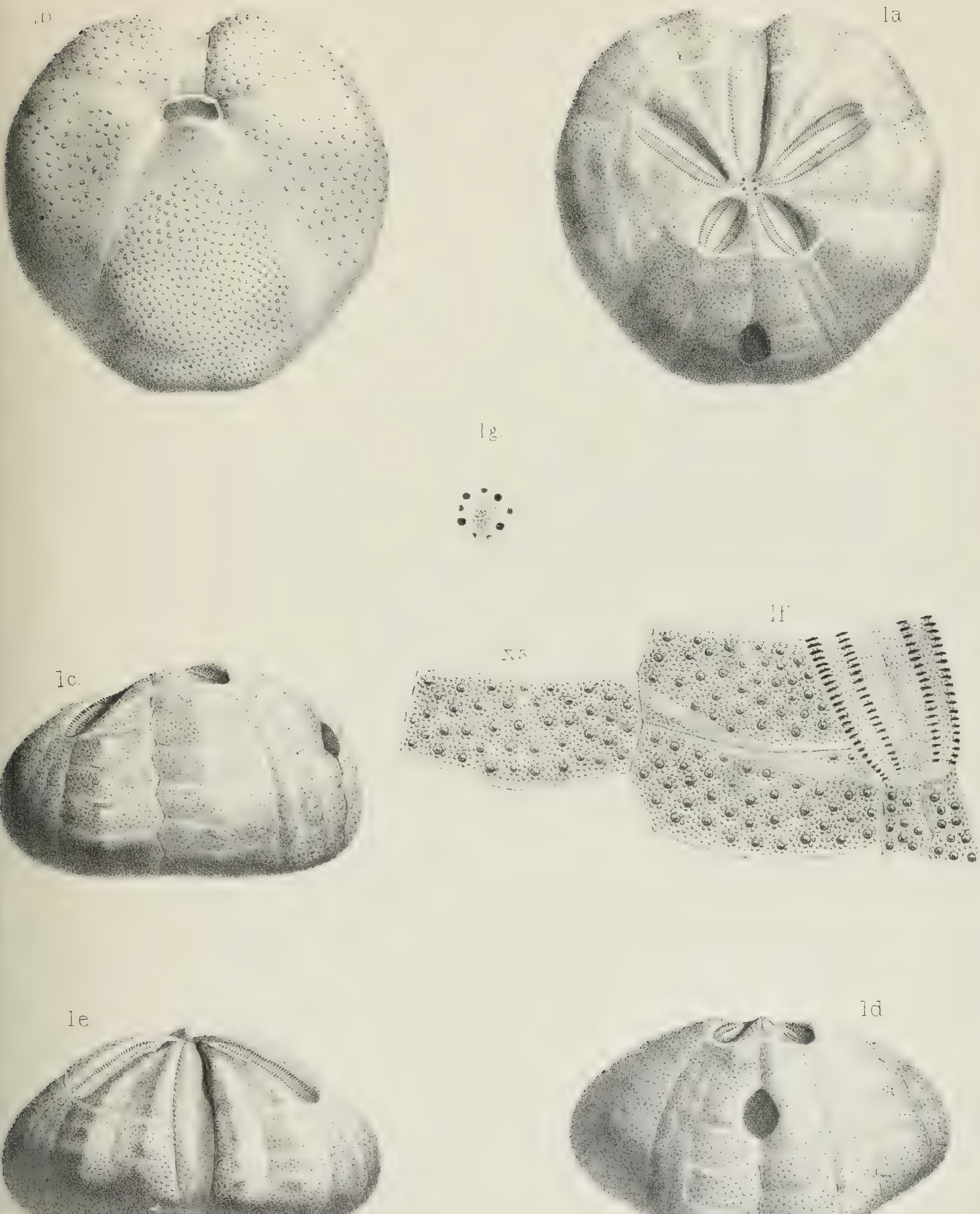
c. Do. lateral view do.

d. Do. posterior do. do.

e. Do. anterior do. do.

f. Ambulacral and inter-ambulacral plates, with poriferous zones, magnified three times.

g. Apical disc, magnified three times.



et lith

F Waller Lith 18 Hatton Garden

PLATE LX.

ECHINOSPATAGUS MURCHISONIANUS, *Mantell.*

From the Upper Greensand.

Fig. 1 *a*. Test, upper surface, natural size. British Museum.
b. Do. under do. do.
c. Do. lateral view do.
d. Do. posterior do. do.
e. Apical disc, magnified.
f. Plates with tubercles, the fasciole an artist's mistake.
g. Skeleton structure of the ambulacra and poriferous zones and apical disc.
h. Structure of the anteal ambulacrum.
i. Tubercles, boss, and encircling granules, magnified.

HEMIASTER BAILYI, *Forbes.*

From the Gault.

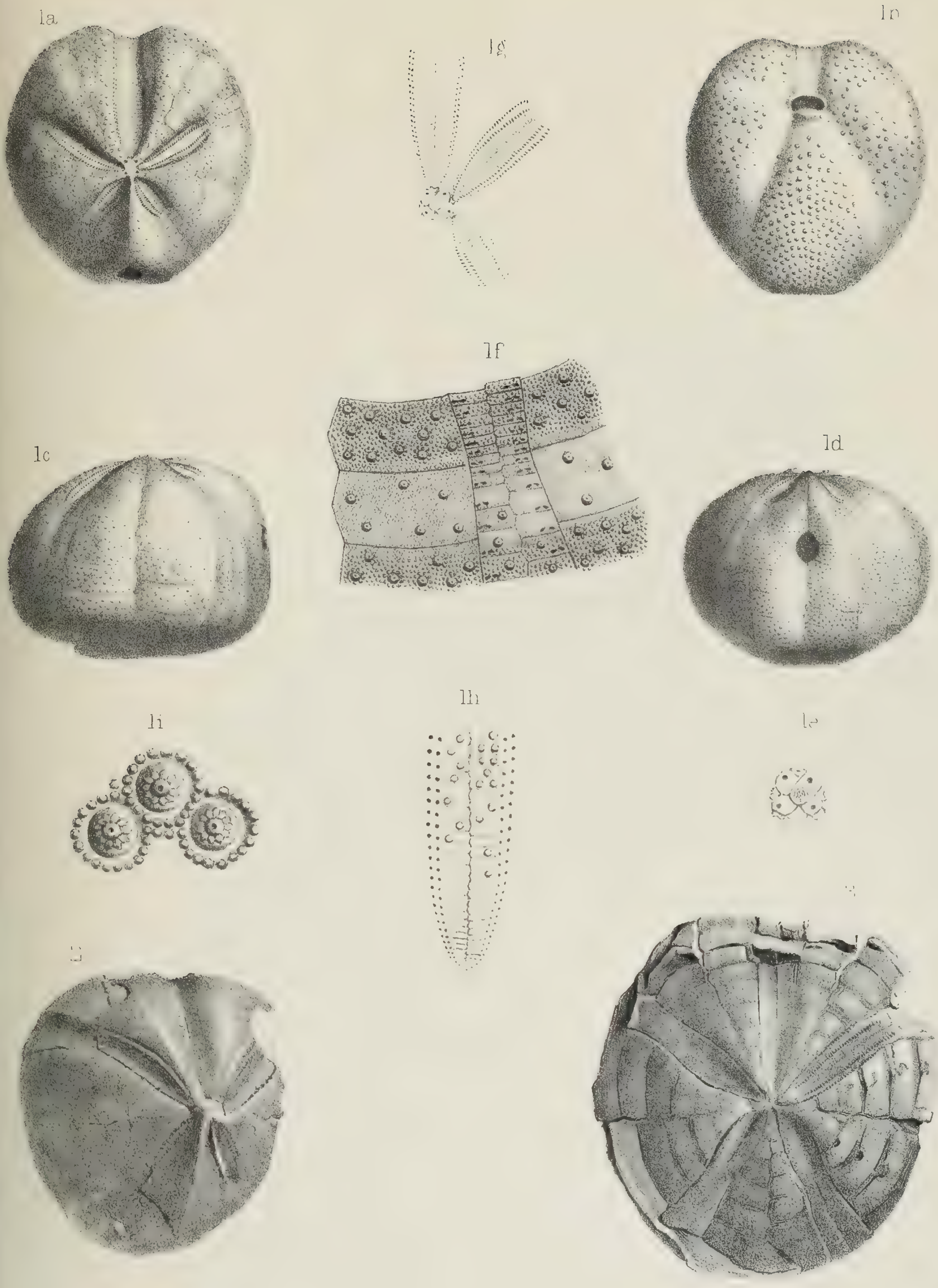
Fig. 2. Test, natural size. Royal School of Mines. (P. 264.)

HEMIASTER ASTERIAS, *Forbes.*

From the Gault.

Fig. 3. Test, natural size. Royal School of Mines. (P. 264.)

Pl. LX



F. Waller lith. 18 Hatton Garden

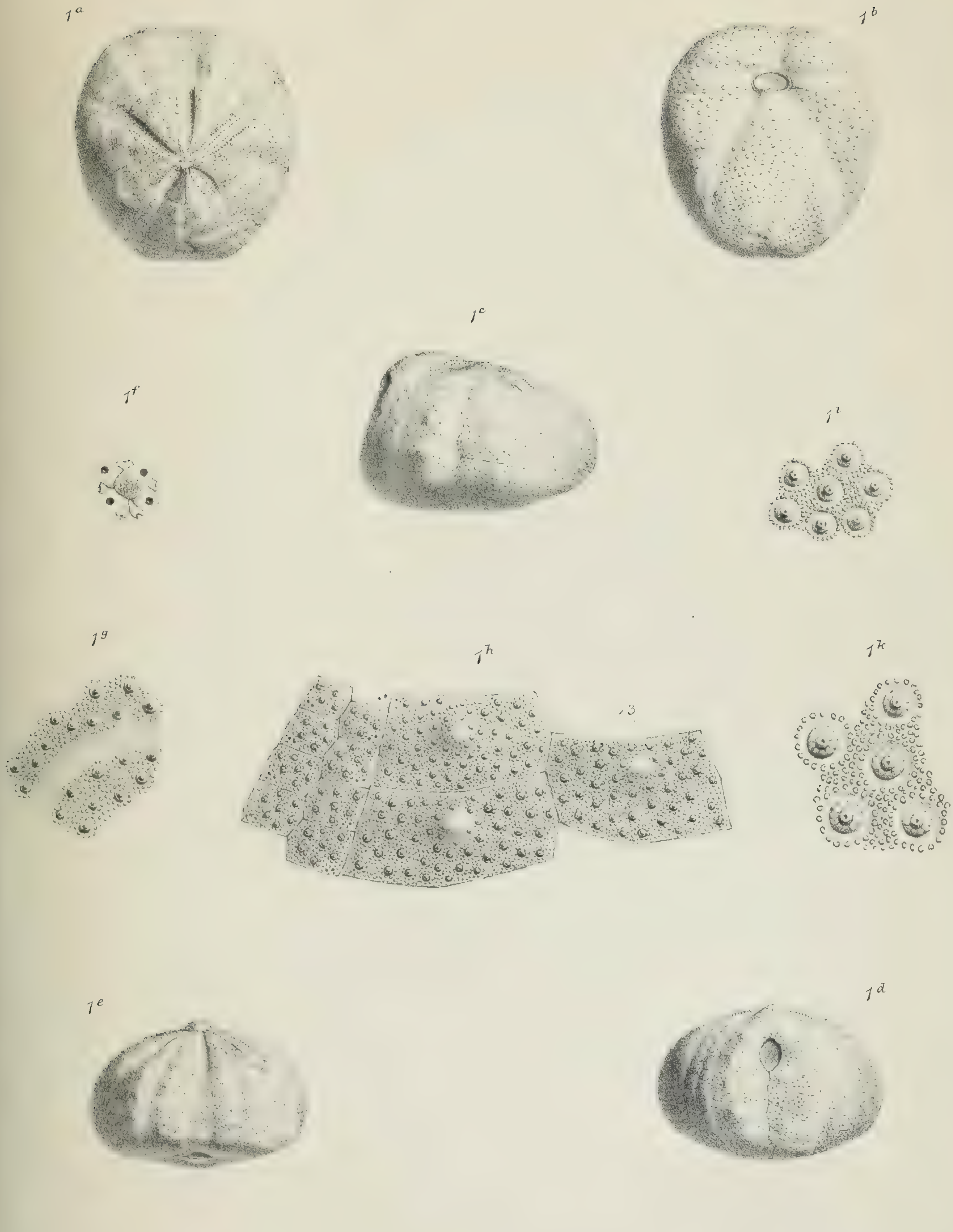
PLATE LXI.

Hemiaster Morrisii, *Forbes.*

From the Grey Chalk.

Fig. 1 *a*. Test, upper surface, natural size. My collection. (P. 262.)
b. Do. under do. do.
c. Do. lateral view do.
Do. posterior do. do.
e. Do. anterior do. do.
f. Apical disc, magnified.
g. Portion of the dorsal plates, showing the peripetal fasciole, magnified.
h. Ambulacral and inter-ambulacral plates, magnified three times.
i. Tubercles and granules on the upper surface, magnified.
k. Tubercles and granules on the under surface do.

Pl. LXI.



C. R. Bone del. et lith.

W. West & Co. imp.

PLATE LXII.

MICRASTER COR-ANGUINUM, *Klein.*

From the Upper Chalk.

Fig. 1 *a.* Test, upper surface, natural size. My collection.

b. Do. under do. do.

c. Do. lateral view do.

d. Do. posterior do. do.

e. Do. anterior do. do.

f. Ambulacral and inter-ambulacral plates, magnified three times.

g. Apical disc, highly magnified.

h. Lateral ambulacra, magnified four diameters.

i. Anterior single ambulacrum, magnified four diameters.

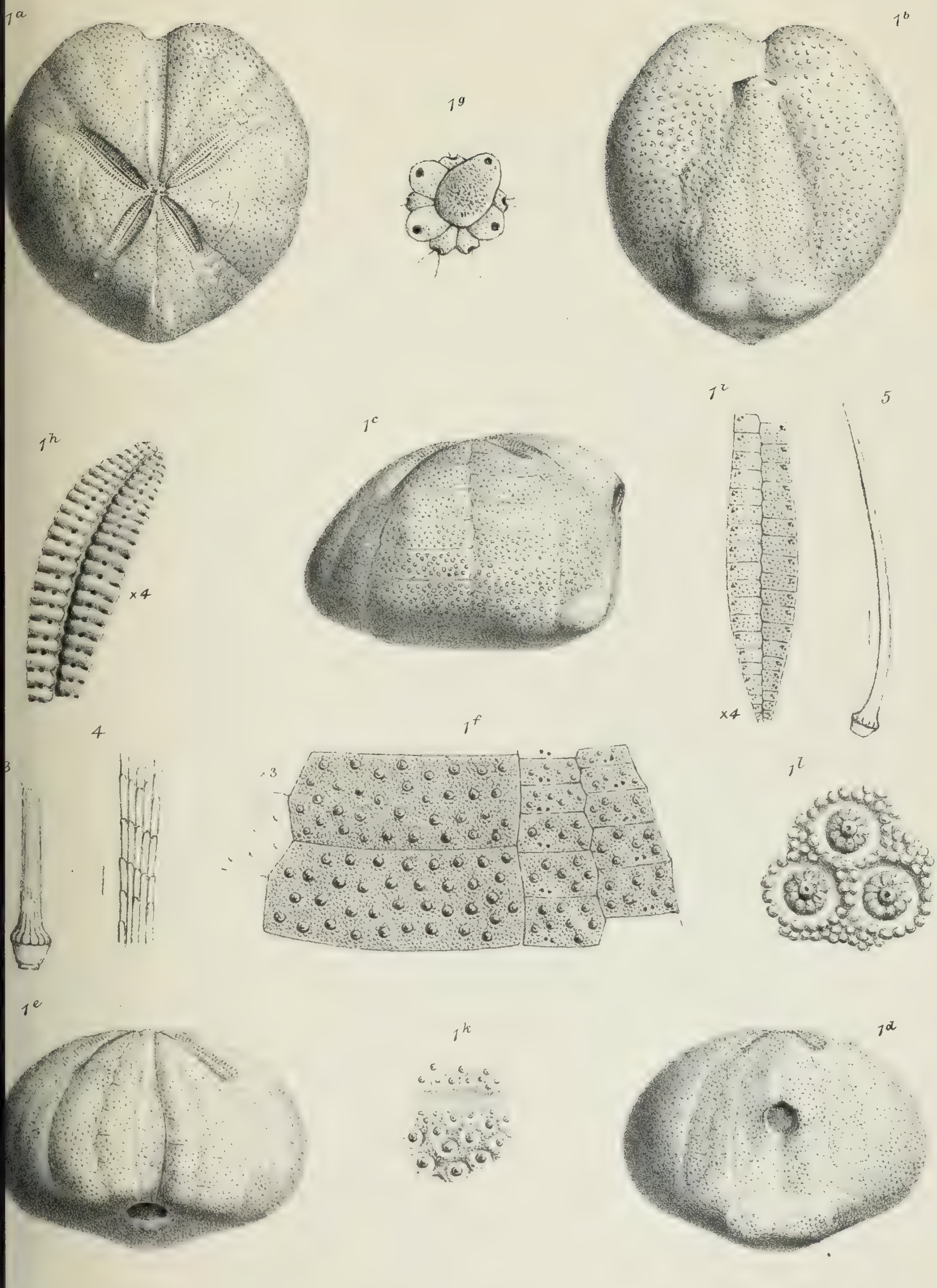
k. Structure of the sub-anal fasciole, magnified.

l. Structure of tubercles, bosses, and granules, magnified.

Fig. 3. Portion of a spine adherent to the test do.

Fig. 4. Do. do. do. do.

Fig. 5. Spine found on the test do.



R. Bone del. et lith.

W. West & Co. imp.

THE

PALÆONTOGRAPHICAL SOCIETY.

INSTITUTED MDCCCXLVII.

VOLUME FOR 1875.

LONDON:

MDCCCLXXV.

A MONOGRAPH

OF THE

BRITISH FOSSIL TRIGONIÆ.

BY

JOHN LYCETT, L.R.C.P.E., &c.

No. III.

Pages 93—148; Plates XX—XXVII.

LONDON:

PRINTED FOR THE PALÆONTOGRAPHICAL SOCIETY.

1875.

PRINTED BY
J. E. ADLARD, BARTHOLOMEW CLOSE

Shell subovate, very convex; umbones prominent, obtuse, antero-mesial, much incurved and slighly recurved; anterior side short, curved elliptically with the lower border; hinge-border short, convex, curving downwards posteally with the siphonal border, the length of which nearly equals that of the hinge-border. Area narrow, its surface forming nearly a right angle with the other portion of the valve; it is slightly concave near to the apex, becoming convex posteally; it is divided by a deeply marked mesial furrow, and is traversed transversely in common with the whole shell by delicate lines of growth; it is bounded by two small carinæ, which are conspicuous near to the apex; the marginal carina has a few small distantly arranged tubercles; the inner carina is also slightly knotted. The escutcheon is small, depressed, but becomes somewhat elevated at its upper border. The ante-carinal space is remarkable for its great breadth, which at the pallial border exceeds that of the area, and is equal to one third of the length across the valve, its upper portion forms a considerable concavity. The anteal or costated portion of the shell is comparatively narrow, occupying only half the surface of the valve; the costæ are plain, oblique, and have some irregularity, curving downwards from the anterior border, and terminating abruptly at the smooth and more depressed ante-carinal space; for the most part their posteal extremities become irregularly nodose. An arrest of growth or concentric sulcation occurs beneath the middle of the valve; the costæ subsequently have less obliquity, or are more concentric, curving upwards anteally, and externally to the extremities of the costæ upon the upper half of the valve.

The large proportion which the smooth ante-carinal space bears to the other portions of the surface, together with the few, plain, oblique, and irregular series of short anteal costæ, constitute the most conspicuous distinctive characters.

Our figure is taken from a gutta-percha pressing of an external cast in the collection of Mr. Cunnington, and was obtained by him in the Portland Oolite of the vicinity of Devizes; a second specimen in a condition nearly similar is in the same collection. Specimens of the typical form of *T. Michelotti* from the Kimmeridge strata of Boulogne were figured by Goldfuss under the name of *Lyrodon excentricum*, and by De Loriol under that of *Trigonia Michelotti;* it was also described and stratigraphically determined by Professor Hébert under the name of *T. Munieri;* it has a lower position than that of our Devizes specimens; the Boulogne shell also possesses some conspicuous distinctive features; the figure is more lengthened, the umbones are much less elevated, and less recurved; the short anteal costæ are less prominent, or are somewhat obscure, and are therefore not nodose; the carinæ have less distinctness, and are without tubercles. These differences are of considerable importance, and were they founded upon a sufficient number of specimens, both French and British, there would remain no doubt of the propriety of separating them as species, but with the very limited materials of either form at my disposal or brought under my notice, and knowing the variability exhibited by some of the *Trigoniæ Glabræ* of the Portland

formation, more especially by the two more abundant of its forms, *T. gibbosa* and *T. Damoniana,* I prefer to regard (provisionally at least) the two allied forms from Boulogne and Devizes as constituting only well-defined varieties of one species.

Dimensions.—Length 16 lines, height 13 lines, thickness through a single valve 4 lines.

TRIGONIA EXCENTRICA, *Park.* Plate XX, figs. 5, 6; Plate XXI, figs. 6, 7; Plate XXII, figs. 5, 5 *a*.

TRIGONIA EXCENTRICA, *Parkinson.* Org. Rem., vol. iii, pl. xii, 1811.
— SINUATA, *Ib.* Ibid., fig. 13.
— EXCENTRICA, *Sow.* Min. Conch., vol. iii, p. 11, tab. 208, figs. 1, 2, 1821.
— AFFINIS, *Miller* and *Sow.* Ibid., tab. 253, fig. 3, 1821.
— — *Defrance.* Dict. des Scien. Nat., tab. lv, p. 297, 1828.
— — *Pusch.* Polens, Paléontologie, p. 61, 1837.
— EXCENTRICA, *Ib.* Ibid.
— — *Agassiz.* Trigonies, p. 9, 1840.
— AFFINIS, *Ib.* Ibid., pp. 9 et 52, 1840.
— EXCENTRICA, *D'Orbigny.* Prodrome de Paléont., 1850, vol. ii, p. 160, No. 328.
— SINUATA, *Ib.* Pal. Franç., Terr. Crét., tom. iii, p. 147, pl. 293, 1843.
— — *Ib.* Prodrome de Paléont., vol. ii, p. 161, No. 323, 1850.
— — *Morris.* Catalogue, p. 229, 1854.
— EXCENTRICA. *Ib.* Ibid., p. 228, 1854.

Shell inequilateral, subovate, rather depressed and thin in the very young condition, becoming thick, with a considerable convexity, in an advanced stage of growth; umbones pointed, erect, little produced, situated about two fifths the length of the valve from the anterior border. Anterior side produced, its border curved elliptically with the lower border; hinge-border nearly straight, or in some examples slightly concave, sloping obliquely downwards, lengthened, terminating in a posteal extremity, which is rounded but attenuated. Area narrow, slightly concave near to the umbo, where the valve forms an oblique angle, separating the area from the anteal portion; the angularity soon disappears, the area then acquires some convexity, and has no distinct separation from the other portion of the surface excepting that a space anteal to the area becomes somewhat depressed near to the lower or pallial border. The other portion of the shell is covered by a series of very numerous, inconspicuous, slightly elevated, longitudinal or horizontal costæ, which are indented anteally by oblique intersecting lines of growth; the costæ are regular and distinct, crossing the entire valve near to the umbo, but they soon disappear over the posteal third of the surface, and examples of adult growth have the

costæ everywhere evanescent near to the pallial border, where the surface is occupied almost solely by the lines of growth, which are large, irregular, and rather distantly arranged. Several sulcations or arrests of growth are usually visible at irregular intervals. The costæ have their anteal portions horizontal or directed slightly downwards; this excentrical direction has been depicted both by Parkinson and by Sowerby in a manner somewhat exaggerated where the costæ are crossed by oblique lines of growth.

The length compared with the height is as ten to seven, or, as in other examples, as ten to eight.

The hinge-teeth diverge widely, and are larger than is usual in the *Glabræ;* the adductor scars are deeply impressed, more especially the anteal adductor, which forms a deep sinus, passing upwards towards the apex of the valve concealed by the anterior dental process in each valve; the borders of the valves are plain, their inner surfaces exhibit remains of the iridescent nacre in well-preserved specimens.

The figures upon Plate XX illustrate the young condition of the species; fig. 6 closely resembles the *T. sinuata* of Parkinson; fig. 5, a specimen of much more advanced growth, retains the surface ornaments similar to the smaller specimen; Plate XXI, fig. 6, and Plate XXII, figs. 5, 5 *a*, represent common examples of *T. excentrica* in which the umbonal portion of the test does not retain the characters of the surface; the large specimen, Plate XXI, fig. 7, which agrees with the *T. affinis* of the 'Mineral Conchology,' has the valve thickened from advanced growth, and the horizontal costæ are obscure. Much of the variability seen in this species is produced by differences in the general figure which are not dependent upon any one stage of growth; thus, the short and thick example fully developed, depicted upon Plate XXI, which fairly represents the *T. affinis* of the 'Mineral Conchology,' is nearly allied in figure to certain young forms which are only three or four lines in length; these latter also pass gradually into the undoubted young condition of *T. excentrica*, Plate XX, fig. 6, which is more lengthened. The six figures upon our plates, although exhibiting much diversity of aspect, do not sufficiently exemplify the medium-sized and fully developed forms of the more lengthened specimens; through the kindness and discrimination of Mr. Vicary this defect may be rectified, that gentleman having recently forwarded to me so considerable a series of specimens from the Greensand of the Blackdown region as to enable me both to verify the unity of these three supposed species and to select from them specimens exhibiting the surface ornaments of the umbonal portions of *T. excentrica* and their identity with the small specimens commonly referred to *T. sinuata*. These will be given upon a future plate.

Dimensions.—Length of the largest of our specimens $2\frac{3}{4}$ inches, height $2\frac{1}{4}$ inches, convexity of a single valve $\frac{3}{4}$ inch. Occasionally the species attains larger dimensions.

Affinities.—The umbonal portion of the shell in the posteal sinuation of its delicate

costæ resembles a similar feature in *T. semiculta,* Forbes, from the Cretaceous rocks of Verdachellum, near Pondicherry, Southern India (see the description of *T. aliformis*); in the Indian species the costæ are much larger, and the posteal slope or area forms a greater angle with the other portion of the valve.

A similar feature is also conspicuous in *T. Sanctæ Crucis,* Valang, (Pictet, Paléon. Suisse,' plate 128, figs. 1—5). The latter shell has the anterior side shorter and its umbones more obtuse; the anteal portions of its costæ are also less distinctly horizontal or excentrical.

For *T. Coquandiana,* D'Orb., which is also an allied form, see the next species.

Owing to the fragility of the test, and the more compact matrix, specimens in Greensand collections are usually very imperfect, and afford no adequate means for testing the distinctness or affinity of other examples of the *Glabræ* from the same formation. These remarks also apply to specimens upon the tablets in the two national metropolitan museums, and enhance the value of the aid which has been afforded by the contribution from the collection of Mr. Vicary.

As both *T. excentrica* and *T. sinuata* are figured upon the same plate in the 'Organic Remains' by Parkinson, neither form possesses priority; I have made *T. sinuata* a synonym, as it exemplifies only the very young condition of the more fully developed *T. excentrica.* The internal mould does not appear to have been identified. The valves are always disunited.

Stratigraphical Positions and Localities.—T. excentrica in its different aspects occurs in the Greensand of the Blackdown and Haldon regions at several localities, as at Hembury Fort, at Staple Hill, and near to Collumpton. The Chloritic Marls and Sandstones at Dunscomb Cliffs, to the eastward of Sidmouth, is another locality.

D'Orbigny records *T. sinuata,* including *T. affinis,* in the lower beds of his Terrain Turonien or Chloritic Chalk of the Ligerian and Pyrenean basins; the localities given by him are Mans, Saint-Calais, Coudrecieux (Sarthe), Fouras, and the Isle d'Aix (Charente Inférieure), Ambillon (Marne et Loire). He retained *T. excentrica* as distinct from *T. sinuata,* but the only locality attached to it is Blackdown.

TRIGONIA LÆVIUSCULA, *Lyc.*, sp. nov. Plate XXII, fig. 6.

Shell depressed, lengthened; umbo moderately produced, small, placed upon the boundary line of the anteal third of the valve and slightly recurved; anterior and lower borders rounded elliptically; superior border somewhat concave; posteal extremity of the valve produced, attenuated, and depressed, its outline rounded. The portion of the valve adjacent to the posteal or superior border is slightly convex, and is without any

angular division ; its surface is smooth, or traversed only by delicate lines of growth. The other portion of the surface has horizontal, broad, depressed, plain, slightly irregular, and unequal ridges, which over the middle and lower portion of the valve become evanescent posteally ; the space thus rendered plain has three or four obscure longitudinal sulcations, and is somewhat more depressed than the costated portion ; its boundary anteally is nearly perpendicular, and extends somewhat anteal to the posteal third of the valve. The umbonal costæ are very delicate and closely arranged ; near to the pallial border the costæ become widely separated, irregular in their directions, and more obscure.

The lines of growth are very delicate, they decussate the horizontal anteal extremities of the costæ.

Internally the borders of the valves are smooth, the test is rather thin, and the hinge dental processes have but little prominence. I have no knowledge of the internal mould.

This fine specimen was obtained by Mr. Vicary, of Exeter, in the Greensand of the Blackdown Hills, near to Collumpton, Devon ; it is shorter posteally than *T. longa*, Ag., and its few lower costæ are more widely separated and irregular. Compared with *T. excentrica*, Park., the latter has the general figure shorter, more especially anteally ; the convexity is much greater, the umbones are more conspicuous, and the longitudinal ridges are less widely separated. The test generally has greater thickness, and the hinge dental processes project more considerably ; the posteal smooth, wide, depressed space in *T. læviuscula* is also distinctive.

Mr. Meÿer has obtained the species ill preserved in chloritic sandy marl at Dunscomb Cliffs between Beer Head and Sidmouth ; these imperfect specimens and the single example herewith figured are only materials known to me.

More especially allied to *T. Coquandiana*, D'Orbigny (' Pal. Fran.,' vol. iii, pl. 294,) for which the imperfect specimens first collected were mistaken. It differs from the species of D'Orbigny in the following features : the convexity of the valves is less ; the posterior extremity is shorter or more rounded ; the costæ disappear altogether over a considerable portion of the surface posteally ; there is also no indication of the little intercalated rib between each of the rows, as in *T. Coquandiana ;* the latter species has the costæ well defined and passing across the valve continuously its entire length.

TRIGONIA LINGONENSIS, *Dum.* Plate XXII, figs. 1, 1 *a*, 2, 3, 4.

TRIGONIA LINGONENSIS, *Dumortier.* Études Jurrassiques du Rhône, p. 275, pl. xxii, figs. 6—8, 1861.
— — *Tate.* Discovery of the oldest known Trigonia in Britain, 'Geol. Mag.,' vol. ix, No. 97, p. 306, 1872.

Shell ovately trigonal, very convex; umbo antero-mesial, pointed, much produced, and slightly recurved; anteal, lower, and posteal borders curved elliptically; hinge-border nearly straight, sloping obliquely downwards, and forming an obtuse angle with the rounded siphonal border of the area. Escutcheon wide, depressed, traversed by transversely oblique, delicate plications, which become conspicuous and more strongly marked upon the obtuse inner carina. Area concave, bounded by two raised, obtusely rounded prominences or carinæ, traversed mesially for about a moiety of its length by a small furrow; both the area and its carinæ are traversed obliquely by very numerous unequal rugose elevations; near to the umbo these form a row of minutely knotted papillæ upon the border of the narrow ridge-like, inner carina. The marginal carina is distinct and elevated only as compared with the area, but has no distinctiveness or separation when compared with the other portion of the shell whose rugæ pass across it without interruption; near to the apex, however, it becomes elevated, narrow, and ridge-like, and the surface anterior to it has densely arranged acute rugæ. The other portion of the surface has a numerous irregular and unequal series of rugæ, which take the direction of the lines of growth; all originate at the pedal border as narrow, densely arranged plications, which become less conspicuous and nearly evanescent upon the middle of the valve; they are continued uninterruptedly across the area and escutcheon. There are also, in some instances, several longitudinal sulcations which are conformable with the rugæ in their direction, and are similarly unequal in their distinctness and distances; other specimens are nearly destitute of these sulcations. The area forms nearly a right angle with the other or pallial portion of the valve, so that, when a specimen is placed in a horizontal position and viewed from above, the area and escutcheon are scarcely visible.

Dimensions.—The largest of the specimens herewith figured has the length, measured from the apex to the posteal extremity, 28 lines; from the upper extremity of the siphonal border across the valve, at right angles to the length, 24 lines; thickness through the single valve $9\frac{1}{2}$ lines, length of the siphonal border 10 lines, length of the superior border of the escutcheon 18 lines.

These dimensions do not refer to the largest specimen obtained, as they are exceeded by one in the museum of the Philosophical Society at York; very rarely also the valves are found in position.

The hinge dental processes are exposed in two of the specimens figured; they agree with those of the *Glabræ* generally, and are less massive than in those of other Jurassic sectional forms. The internal mould has the adductor scars well developed; there are also traces of the external encircling rugæ; the test appears to be thin. The external rugæ differ much in their prominence in different specimens, so that in some instances the general surface is smooth, and has rugæ only near to the pedal border.

M. Dumortier described *T. Lingonensis* from the Marlstone beds of the valley of the Rhone, near to Langres; his figure has a slight depression of the surface anteal to the angle of the valve. None of the British specimens possess this feature, which probably, therefore, is only accidental.

Mr. R. Tate, now a resident at Redcar, to whom we owe its discovery as a British species, states that it occurs in the main seam of ironstone throughout the Cleveland district in the zone of *Ammonites spinatus*, and that it has been obtained at the following localities:

Skinningrone mines; Hobb Hill mine, near Saltburn; Eston mines, near Middlesboro'; Belman Bank and Challoner mines, near Guisborough; that the species is rare, excepting at Eston, but well-preserved specimens are everywhere rare. The two larger of our specimens were obtained by Mr. G. Lee, manager of the Eston mines at that locality, and generously presented by him for the present Monograph.

Examples of this remarkable Trigonia are in the museum of the Royal School of Mines; in the museum of the Yorkshire Philosophical Society; in the collection of Mr. R. Tate at Redcar; in that of Mr. G. Lee at Eston; and in my own cabinet—all from the ironstone of the Cleveland district. The British Museum has a specimen obtained by the late Miss Baker, of Northampton, in the Middle Lias at Preston Capes in that county; no other example from the Lias of the midland or southern counties has come under my observation.

Affinities.—The almost entire absence of ornaments upon the surface associates it with the *Glabræ*, a section which has only a small number of ascertained species, and, unlike other sections of the genus, is not limited to one portion of the Mesozoic period, but occurs at intervals widely separated stratigraphically; thus, the *Clavellatæ*, the *Undulatæ*, and the *Costatæ*, are limited almost exclusively to the Jurassic formations. The *Quadratæ* and the *Scabræ* are not less strictly Cretaceous forms, but the *Glabræ*, although represented by few species, constitute a section which embraces nearly the entire limits of the Mesozoic period.

T. Lingonensis, the oldest known Trigonia, is limited to the Middle Lias. The next known example of the section is our *T. Beesleyana*, which occurs not less rarely in the Inferior Oolite at a single locality. From that position the section appears to be absent until we arrive at the Portland formation, where it becomes the predominating section of the genus, and is represented in Britain by five species, two of which are abundant. Again, after a long stratigraphical interval, the section reappears in the middle portion of

the Cretaceous rocks represented by two species in the Devonshire Greensand and Upper Greensands and Chloritic Marls of the South Devon coast. Two other European forms are also recorded. The Cretaceous rocks of India have yielded to the researches of Forbes and of Stoliczka four characteristic examples of the section. It is chiefly in the Cretaceous examples of the *Glabræ,* both European and Asiatic, that we discover affinities with the Liassic *T. Lingonensis,* species placed almost at the opposite stratigraphical limits of the Mesozoic formations; these affinities, however, have only a general or sectional resemblance, and refer chiefly to the characters of the area, so little separated from the pallial portion of the surface.

§ V. Quadratæ.

In Britain the *Quadratæ* are represented by four species only, two of these each constitute two varieties; they possess the several features special to the section prominently developed. Externally their escutcheons have small nodose varices; internally the posteal portion of the pallial border has a short row of quadrate pits and elevations; there is also a smaller oblique series of pits or furrows at the posteal extremity of the hinge-border. Plate XXIV, fig. 1 *a*, exemplifies the pallial pits of *T. nodosa. T. dædalea* and *T. spectabilis* have less than half the number of these pits upon their inner surfaces.

Trigonia dædalea, *Park.* Plate XXII, figs. 7, 8; Plate XXIII, figs. 2, 3. Var. *confusa,* Plate XXIII, fig. 1.

Trigonia dædalea, *Parkinson.* Org. Rem., vol. iii, pl. xii, fig. 6, 1811.
— ? rudis, *Ib.* Ibid., fig. 10.
— dædalea, *Sowerby.* Min. Conch., vol. i, tab. lxxxviii, 1815.
— quadrata, *Ib.* Geol. Trans., 2nd series, vol. iv, pl. xvii, fig. 10 (young example), 1836.
— dædalea, *Pusch.* Polens, Paléont., p. 60, 1837.
— — *Agassiz.* Trigonies, p. 52, 1840.
— palmata, *Deshayes.* Leymerie, Mém. Soc. Géol. Franç., vol. v, pl. viii, fig. 5 (variety), 1842.
— quadrata, *Morris.* Catalogue, p. 229, 1854.
— dædalea, *Ib.* Ibid., p. 228 (pars). Exclude Lower Greensand.

Exclude the *Trigonia dædalea* of the following authorities:

De la Beche, Geological Manual, p. 287, 1832.
Mantell, Geology of the South-east of England, Appendix, p. 388, 1833.

Ibbetson and Forbes, Proc. Geol. Soc., vol. iv, p. 414, 1844.
Fitton, Quart. Journ. Geol. Soc., vol. iii, p. 317, 1847.
D'Orbigny, Paléontologie Française, Terr. Cret., vol. iii, p. 145, pl. 292, 1843.
Ib., Prodrome de Paléont., vol. ii, p. 161, No. 322, 1850.
Pictet and Renevier, Foss. du Terr. Aptien de la Perte du Rhone et des Environs de Ste. Croix, pl. xii, fig. 1, 1857.

The figure of *T. dædalea* is ovately quadrate and depressed; the apices are small, pointed, slightly recurved, anteal and terminal; the hinge-border is short and slightly rounded, forming nearly right angles with the anterior and posterior borders; the latter or siphonal border is equal in length to the hinge-border, its lower extremity is curved; the lower border is curved elliptically with the anterior border. The area constitutes half the surface of the valve; it is flattened, without any distinct mesial division, excepting near to the umbo; its separation from the costated portion of the surface forms an angle which is slightly ridge-like where it is crossed by the first-formed or apical costellæ; there is, therefore, no distinct marginal carina; the positions of the inner and median carinæ are each indicated by an ill-defined row of small, rounded, widely separated tubercles; there are also numerous, small, irregular depressed tubercles scattered confusedly over its surface, and also some transverse rugose plications posteally. The upper or apical portion of the area has about eight rows of narrow, ridge-like, delicately knotted costellæ, which, originating at the anteal portion of the superior border, and passing across the valve obliquely downwards, enlarge rapidly and become rounded after they have passed the divisional angle, forming tuberculated varices about the middle of the costated portion of the valve, where they are bent suddenly upwards to the anteal border, each forming nearly a right angle; these are succeeded by several short supplementary varices, which pass backwards horizontally from the anterior border until they are interrupted by the short bent varices. The remaining portion of the surface is occupied by about eight larger, curved rows of tuberculated varices, each row having about nine distinct rounded tubercles; the rows commence at the angle of the valve and enlarge rapidly downwards towards the pallial border, the smallest tubercle in each row is, therefore, at the angle of the valve or at the usual position of the marginal carina. The escutcheon is narrow, lengthened, and flattened; it has several obscure rugose varices. The fragment figured by Parkinson, which has priority as an example of this species, appears to represent a specimen with the apical portion of the ornamentation unusually small and more than usually irregular anteally. This arrangement differs somewhat from the fine adult specimen figured in the 'Mineral Conchology,' but approximates to some of the Blackdown examples (see Plate XXII, fig. 7). The few first-formed rows of varices form, in some specimens, angulated ridges, which are only slightly tuberculated, resembling the little *T. quadrata*, Sow., but commonly, as in the figure of Parkinson, the first-formed rows are distinctly tuberculated. The interiors of

the valves have the cardinal teeth much smaller and less prominent than in *T. nodosa* and *T. spectabilis;* the pallial posteal pits and elevations are small, closely arranged, and only three in number, thus affording a contrast to the same feature in *T. nodosa,* which has them much larger and greatly more numerous, so that in that species they occupy much of the surface near to the pallial border.

The foregoing detailed description will, it is trusted, suffice to rectify an error into which some palæontologists have fallen, who have taken for their guide the figure of *T. dædalea* in the 'Mineral Conchology' of Sowerby, an inaccuracy in the drawing having produced much confusion from its supposed identity with that fine variety of *T. nodosa* of which such considerable numbers have been obtained in the beds called "Crackers" in the Neocomian formation at Atherfield. Sowerby's drawing of *T. dædalea* has the angle of the valve occupied by a row of rounded nodes, which are larger than those in the adjacent rows of varices and have no accordance with them either in number or position. This arrangement differs materially from the original specimen now in the British Museum, but has much resemblance to the corresponding parts in *T. nodosa.* As the figure of *T. dædalea* in the 'Mineral Conchology' represents the only example of adult growth to be found in any British work since the fragment figured by Parkinson, our figures are the more deserving of scrutiny and comparison.

The variability so frequent in the ornamentation of the surface in the typical form may now be adverted to. Occasionally the minute tubercles upon the area are arranged with regularity, forming oblique rows which curve upwards and backwards from the angle of the valve. Another arrangement has the row of small nodes upon the angle of the valve, assuming the same comma-like figure which is so conspicuous in the larger carinal nodes of *T. nodosa;* however, this feature is scarcely ever distinct upon the whole of the row. Near to the pallial border, occasionally, are one or several short supplementary rows of varices resembling the same feature which is common in *T. nodosa.* The internal mould appears to be unknown.

A larger and well-marked variety of *T. dædalea,* var. *confusa,* is illustrated by Plate XXIII, fig. 1, which represents a specimen obtained by Mr. Vicary, of Exeter, in the Greensand of Little Haldon; it is distinguished by the generally increased size of the several features which ornament the surface, by the larger pallial varices and their nodes, and more especially by the unusually large, confusedly irregular, and unequal nodes scattered over the area; there is also a series of short anteal supplementary pallial varices, several of which are intercalated with the anteal extremities of the large oblique varices. This variety is rare, no second specimen has come under my notice.

Measurements of two examples of the typical form in my collection :

No. 1.—Length across the valve	. . .	29 lines;
Height	. . . . .	25 lines;
Length of the escutcheon	. . .	17 lines;
Length of the siphonal border	. .	17 lines;
Across the area	. . . .	16 lines;
Across the pallial surface	. . .	18 lines.

No. 2.—Length across the valve	. . .	24 lines;
Height	. . . . .	22 lines;
Length of the escutcheon	. . .	15 lines;
Length of the siphonal border	. .	15 lines;
Across the area	. . . .	11 lines;
Across the pallial surface	. . .	12 lines.

Specimens of less mature growth have the length and height equal, the measurement across the area is also equal to that across the pallial surface.

Stratigraphical positions and Localities.—The typical form of *T. dædalea* is not uncommon in the lower beds of Greensand at several localities in the Blackdown region, more especially in the Whetstone Pits near to Lyme Regis, Honiton, and Collumpton.

The south-western outliers of the Greensand at Great and Little Haldon have not produced the typical form, excepting in its very young condition. It appears to be also absent in the coast sections of Upper Greensand and Chloritic Marls upon the coast of South Devon, and equally so at the Isle of Wight, in Wiltshire, and in Kent and Sussex, and as no foreign example is known it may be presumed to have been a species eminently localised and restricted to a very limited area.

The large variety *confusa*, Plate XXIII, fig. 1, was obtained by Mr. Vicary at Little Haldon, near Dawlish, in the second bed of Greensand, which underlies the bed with Orbitulites. As these latter fossils are abundant and do not occur at Great Haldon, which is separated from the other hill only by the narrow valley of Escombe, Mr. Vicary inclines to the opinion that the upper beds at Little Haldon are somewhat higher in the series than the other. The pebbly stratum enclosing Greensand fossils, including *Trigonia pennata*, *T. sulcataria*, and *T. Vicaryana*, with numerous other forms well preserved, caps the hills both of Great and Little Haldon. These *Trigoniæ* do not occur in the Blackdown region.

Affinities and differences.—The only figure of *T. dædalea*, other than those of Parkinson and of Sowerby, which has come under my notice is a variety which constitutes the *T. palmata* of Deshayes (Leymerie, 'Mém. Soc. Géol. Fr.,' sér. 2e, vol. v, plate viii, fig. 5). Compared with British specimens, the small but distinctly raised marginal carina is destitute of nodes; the rows of pallial varices are much fewer; small at the

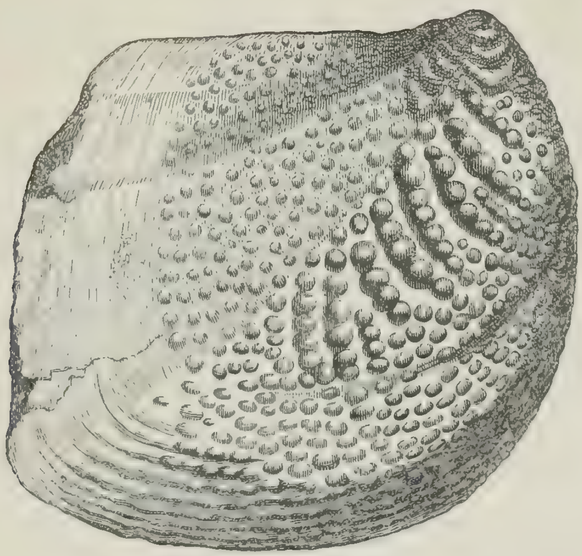
carina, they enlarge rapidly downwards towards the pallial border; the spaces between the rows are plain and very wide. This well-marked variety has not been observed in Britain.

The fine specimen of *T. dædalea* figured in the 'Mineral Conchology,' now in the British Museum, having so frequently been regarded as identical with the variety of *T. nodosa* so abundant in the beds called "Crackers" of the Neocomian formation at Atherfield, a comparison of the two forms becomes necessary. *T. dædalea* has much less convexity; this feature alone will usually be sufficient to separate them; it is also shorter in the general figure, more especially upon the superior border, which has the escutcheon small and inconspicuous. The area is more flattened and its ornamentation is much more minute; it is much less decidedly bipartite, or is without the concavity formed by the upper half of the area in *T nodosa.* Its three rows of carinal nodes upon the apical portion of the valve are minute, very numerous, and closely arranged, so that the transverse ridges which cross that portion of the area and are continued to the anteal border of the valve are also greatly more numerous and closely arranged. The rows of pallial varices have greater curvature, they pass upwards towards the angle of the valve almost perpendicularly, or form a much greater angle with it than is seen in *T. nodosa;* the nodes in the rows are also more elevated and pointed; they lessen in size rapidly and regularly from the border upwards, so different from the irregular and unequal nodes in *T. nodosa,* which, for the most part, have the largest nodes about the middle of the rows. But apart from these details, a first glance at the depressed, short figure of *T. dædalea* will usually suffice to separate it from the Neocomian species.

The foregoing details will also serve sufficiently to separate the Devonshire *T. dædalea* from that different example of the *Quadratæ* afforded by the Greensand of Le Mans, with which, misled by Parkinson's very insufficient figure, Deshayes and D'Orbigny united it. Sowerby ('Geol. Trans.,' 2nd series, vol. iv, pl. xvii, fig. 10) depicted a very young, almost embryotic example of *T. dædalea* under the name of *T. quadrata.* A similar but larger specimen is given, Plate XXII, fig. 8, of the present Monograph; it should be compared with the young example of *T. nodosa,* Plate XXIV, fig. 3. Four years subsequently to the appearance of Sowerby's figure, Agassiz, who had received specimens of *T. dædalea* from England, was therefore fully aware of their distinctness from the large species of Le Mans, figured and described the latter under the name of *T. quadrata* ('Trigonies,' p. 27, tab. vi, figs. 7—9); apparently he was unaware that Sowerby had appropriated that name for his little Greensand specimen. By reuniting the little species of Sowerby to *T. dædalea* the name *quadrata* given by Agassiz to the large species of Le Mans will thus be entitled to remain; it has not been obtained in Britain. Possessing such materials for comparison it is remarkable that Agassiz, upon page 26 of the same work, should have tabulated *T. dædalea,* Park., as identical with a Trigonia from the Portland formation of Besançon, which he figured and described

under the name of *T. Parkinsoni* ('Trigonies,' tab. x, fig. 6), but he avows his uncertainty as to the correctness of this identification. Judging from the drawing upon the plate of Agassiz, it is not identical with any known British species; of its several features the general form alone possesses any similarity to the section of the *Quadratæ* in which that author placed it.

Three years after the publication of the memoir of Agassiz D'Orbigny figured and described the large Le Mans shell for the *T. dædalea* of Parkinson ('Paléont. Fran., Ter. Crét.,' vol. iii, p. 45, plate 292).



Our wood engraving exemplifies *T. quadrata*, Ag., or *T. dædalea*, D'Orbigny; the original is one of a fine series in the British Museum, numbered 32,394; it is remarkable for the great length of the siphonal border, which exceeds that of the upper border of the valve; the absence of any row of nodes at the carinal angle of the valve, the more numerous and smaller rows of pallial nodes, their general confusion, or, in other instances, the attenuation and crowded bifurcation of the rows near to the pallial border, the simple curvature of the few first-formed rows, and the general absence of any distinct separation between the pallial and siphonal portions of the valve, supply very evident distinctive differences. The valves of *T. quadrata* are also more depressed, more thin, their surface ornaments are much less prominent than in *T. dædalea*, their condition of preservation is also less satisfactory; not unfrequently large portions of their surfaces are deprived of the test or have the ornaments imperfectly preserved.

Trigonia nodosa, *Sow.* Plate XXV, figs. 1, 2. *Var.* Orbignyana, Plate XXIV, figs. 1, 1 *a*, 2, 3.

Trigonia clavellata, *Mantell.* Geol. Sussex, p. 73, No. 10, 1822.
— nodosa, *Sowerby.* Mineral Conchology, vol. vi, tab. 507, fig. 1, p. 7, 1829.
— dædalea, *De la Beche.* Geol. Manual, p. 287, 1832.
— — *Mantell.* Geol. of South-east of England, p. 179, 1833.
Trigonia cincta, *Agassiz.* Trigonies, p. 27, tab. vii, figs. 21—23; and tab. viii, figs. 2—4, 1840.
— — *Matheron.* Catal. de Corps Org. Foss. du Départ. des Bouches du Rhone, p. 166, 1842.
— rudis, *D'Orbigny.* Pal. Fran. Terr. Crét., pl. 289, 1843.
— dædalea, *Ibbetson* and *Forbes.* Proc. Geol. Soc., vol. iv, p. 144, 1844.
— — *Fitton.* Quart. Journ. Geol. Soc., vol. iii, p. 317, 1845.
— rudis, *D'Orbigny.* Prodrome de Paléont., vol. ii, p. 78, No. 291, 1850.
— cincta, *Buvignier.* Statist. Géol. Minér. et Paléont. du Départ. de la Meuse, p. 473, 1852.
— nodosa, *Morris.* Catal., p. 229, 1854.
— — *Cotteau.* Moll. Foss. de l'Yonne, p. 76, 1857.
— dædalea, *Pictet* et *Renevier.* Foss. du Terr. Aptien de la Perte du Rhone et des Env. de Ste. Croix, pl. xii, fig. 1, 1857.

Shell ovately oblong, moderately convex anteally and mesially, depressed posteally; umbones small, anterior, pointed, scarcely elevated above the superior border; anterior side very short, its border curved elliptically with the lower border; superior border lengthened, straight, its posteal extremity forming an obtuse angle with the siphonal border of the area, which is sinuated, and its lower extremity curves elliptically with the lower border. Ligament of the hinge occasionally preserved; large, in its absence the ligamental plates are conspicuous in their wide fossa. Escutcheon narrow, horizontal, flattened, its surface with small, oblique, irregular, nodose elevations. Area large, flattened, equal to two fifths of the surface of the valve in the variety *Orbignyana*, or to a moiety of the surface in the typical form; a row of nodes divides the area into two portions, the superior or outer portion is the larger, and is somewhat more depressed than the other, adjacent to the umbo; the area has three conspicuous rows of large depressed nodes, representing the inner, median, and marginal carinæ; the inner carina has its nodes ovately lengthened, and near to the posteal extremity of the escutcheon they become mere plications of growth; the median and marginal carinæ have their nodes more rounded, but often somewhat concave upon their anteal sides, producing a comma-

like figure. This, however, is not constant, and not unfrequently the nodes are ovate or slightly oblong, or in other instances the marginal carina has its nodes unequal in size and irregular in figure; all the rows become evanescent upon the posteal half of the valve, where the area is occupied by large, irregular, knotted, transverse plications; the portion of the area near to the umbo has regular transverse ridges, which are united to the carinal nodes; the whole of this portion of the area has rows of regular, minute, transverse, papillary elevations, more or less distinct, which impart a highly ornamented aspect to the valve. The rows of nodose varices or costæ upon the other or pallial portion of the valve commence, as in some other species, with about seven elevated biangulated, ridge-like rows, which pass obliquely downwards from the anterior border to the middle of the costated surface, where they are bent suddenly and pass uninterruptedly across the area obliquely, forming small elevated nodes at the marginal and median carinæ, and smaller ridges as they are prolonged to the inner carina; the succeeding rows consist of large, closely arranged, rounded varices, curved obliquely downwards from the marginal carina; their nodes usually increase in size downwards in each row; as they approach the pallial border they curve upwards in the direction of the lines of growth; there is some irregularity in the rows of anteal varices which succeed the first-formed plain ridged series; they form a few short supplementary rows, several of which are intercalated with the anteal portions of the oblique rows; the nodes nearest to the carina are smaller than those of the carina, with which they are also unconformable in number, as they are slightly more numerous than the carinal nodes. Owing to the enlargement of the nodes nearest to the pallial border and their more lengthened figures, the aspect of that portion of the valve is sometimes remarkable, the nodes being so closely placed that their arrangement in rows is scarcely perceptible unless the shell is viewed from the anterior side and at a little distance, when their order becomes more evident.

In the variety *Orbignyana* the size and figure of the nodes have commonly great variability and inequality, sometimes even in a single row, so that the anteal or pallial extremities of the rows have the nodes large and ovately lengthened, or in other specimens their anteal extremities are attenuated, their nodes becoming small, cord-like, and indistinct; both kind of rows have their anteal extremities conformable with the lines of growth or with the pallial border. For the most part the variety of the Perna bed or typical form has the rows of varices and nodes rather smaller and more regular (Plate XXV, fig. 1). The rows are more separated; the carinal nodes are also more regular and equal, so that the general aspect has little of the confused and crowded nodes so commonly seen in the variety of the crackers.

Young examples, from five to fifteen lines in length, have the general figure depressed, and are shorter or more quadrate; the area is also in proportion larger; the costæ or varices form plain ridges without nodes.

The "Cracker" variety *Orbignyana* has occurred abundantly at Atherfield, in beds

higher than those which are characterised by the typical form; the former are also found in a better condition of preservation; their profuse and varied ornamentation command general admiration, and require several specimens to exemplify adequately their several aspects; this variability, although considerable, scarcely affects the general figure, and is nearly limited to the ornamentation of the surface; but with so much irregularity in the nodes, description must to some extent become subordinate to figures. The difference of figure supplies the most constant and clear distinction which characterises the two varieties. In the typical form (Plate XXV) the area constitutes a moiety of the valve, and the pallial or costated portion has somewhat less breadth than in the other; the great length of the siphonal border imparts consequently a more quadrate figure to the shell. The variety *Orbignyana* has the costated or pallial portion larger than the area; the siphonal border passes more obliquely downwards, or forms a more obtuse angle with the upper border; the lower or posteal extremity of the valve is therefore more produced and pointed.

The internal moulds are only known to me from the small specimens of *T. cincta* figured by Agassiz; in these the height is less in proportion than in specimens not deprived of the test.

Dimensions.—Specimen of the typical form from the Perna bed at Red Cliff, Sandown.

Length measured upon the marginal carina	30 lines.
At right angles to the carina across the pallial surface	16 ,,
Across the area	15 ,,
Length of the siphonal border	18 ,,
Length of the escutcheon	22 ,,

Dimensions of a specimen from Hythe:

Length upon the marginal carina	40 lines.
At right angles to the carina across the pallial surface	21 ,,
Across the area	19 ,,
Length of the siphonal border	24 ,,
Length of the escutcheon	25½ ,,

Variety *Orbignyana*:

Length upon the marginal carina	39 lines.
At right angles across the pallial surface	21 ,,
Across the area	15 ,,
Length of the siphonal border	18 ,,
Length of the escutcheon	24 ,,
Diameter through the valves	21 ,,
Breadth of escutcheon	8½ ,,

Stratigraphical position and Localities.—*T. nodosa* constitutes two varieties in Britain, the differing characters of which may be stated synoptically as follows:—*The typical form.*—Area forming a moiety of the surface of the entire valve; nodes of the marginal carina small and regular in figure, size, and arrangement; rows of pallial varices regular, without bifurcations, and becoming attenuated near to the border. *Position.*—Perna bed at Redcliff, Sandown Bay, Isle of Wight. Hythe, dark grey sandstone bed with *T. ornata*. *Maidstone*, Molluskite bed. Tealby, brown pisolite bed. *Variety* ORBIGNYANA.—Surface of the area never exceeding two fifths of the entire valve; nodes of the marginal carina unequal in size and irregular in figure and arrangement; rows of pallial varices variable in figure and arrangement, at the border either large and simple or bifurcating and attenuated, the nodes either distinct or crowded. *Position.*—The Cracker beds at Atherfield, Isle of Wight; rarely in the Perna bed at Redcliff, near Sandown.

History, affinities, and comparisons with allied testacea.—For specimens illustrative of *T. nodosa* from the Neocomian sandstone quarries near Hythe, which was the locality of the type-specimen figured by Mr. Sowerby, I am indebted to Mr. Mackeson, of that place, who, in compliance with requests from Rev. T. Wiltshire and myself, obtained several examples; these are obscure moulds of external casts in coarse sandstone. Mr. Mackeson had also the good fortune to procure upon a slab of sandstone two external casts of uncompressed specimens; these have afforded good reproductions of the shell by the aid of gutta-percha pressings, and are found to agree with the form procured at Lympne and in the Perna bed at Redcliff, Sandown Bay. I have also been favoured with information respecting the condition of the species in the quarries of Kentish Rag near Maidstone, in a communication from Mr. J. Bensted, jun., the son of the proprietor of the quarries, whose intelligent remarks I have pleasure in quoting. "It is not uncommon in the Iguanodon quarries, and is found principally in one particular bed of sandstone called *Molluskite bed*, but simply as a faint white mark formed by the lime of the original shells, which are quite valueless as specimens. I have a single specimen only, which owes its preservation to the fact that the space occupied by the shell appears to have been filled with flint, which was to a certain extent able to resist the pressure which squeezed the others flat." The same gentleman also favoured me with a drawing of the fossil which demonstrated its identity as a species with the gutta-percha pressings from Hythe, the specimen from Tealby, and those from the Perna bed at Redcliff; from the latter locality the Royal School of Mines has a large specimen, presented by Dr. Fitton, as an example of *T. dædalea*, but as the surface of the area is ill-preserved it is not fitted for the artist.

Upon the same plate with the fragment figured by Parkinson for his *T. dædalea* ('Org. Rem.,' vol. iii, pl. xii) is another more doubtful fragment, to which he attached the name of *T. rudis;* it supplies a warning example of the impropriety of publishing such materials when no satisfactory description can possibly be founded upon them.

This figure, so worthless in itself, has been the source of confusions and errors of identification in the Cretaceous *Trigoniæ* for upwards of sixty years. One of the most singular and notable of these arrangements is seen in the great work of D'Orbigny above referred to. I am only able to correlate with some doubt Parkinson's fragment of *T. rudis.* The confusedly scattered tubercles upon the area, and the apparent absence of distinct carinal nodes, associate it better with the large variety of *T. dædalea* than with any other species. Professor Morris ('Catalogue,' p. 229) placed *T. rudis* doubtfully with *T. spectabilis.* A slight error in Sowerby's delineation of *T. dædalea* ('Min. Con.,' tab. lxxxviii) gives the appearance of rounded nodes upon the marginal angle of the valve, larger than those upon the adjacent rows of pallial varices; this has been a frequent source of error connected with *T. nodosa*, or rather with its variety *Orbignyana;* specimens of this variety have been freely dispersed over Europe, and have been regarded as examples of *T. dædalea;* it was adopted as such by Ibbetson and Forbes ('Proc. Geol. Soc.,' vol. iv, p. 414), by Fitton ('Quart. Journ. Geol. Soc.,' vol. iii, p. 317), and also by the latter author in his elaborate stratigraphical list of Lower Greensand fossils It is also the *T. dædalea* of Mantell ('Geology of the South-East of England,' p. 179) and of De la Beche ('Geol. Manual,' p. 287). It may afford some explanation of these errors to mention that Sowerby's original figure of *T. nodosa* does not accord very closely with any actual known specimen; the effects of vertical pressure will explain the appearance of flattening at the umbo, the partial exposure of the striated hinge processes, the apparent absence of the angulated costæ upon that portion of the shell. Mr. Sowerby's collections of fossils, now in the British Museum, does not contain the original specimen of *T. nodosa* figured in the 'Mineral Conchology,' and no information concerning it can be obtained; two very indifferently preserved portions of the Trigonia in the collection are probably the "inside casts" mentioned in his description.

Agassiz, in common with other palæontologists, appears to have experienced much difficulty in the determination of this species ('Trigonies,' p. 27, tab. vii, figs. 21—23; table viii, figs. 2—4;) the figures upon his plates are named *T. nodosa;* subsequently he was led to regard the species of Sowerby as distinct, and described the supposed new species under the appellation of *T. cincta.* Agassiz grounds the distinctness of *T. cincta* upon its smaller and more regular varices, upon the greater breadth of its area, and upon the ornamentation of the area, which in *T. nodosa* appears to be nearly smooth, excepting that it possesses carinal nodes. The condition of the Hythe specimens is such that we should not expect to have the ornamentation of the area preserved; usually the size of the area is nearly equal to a moiety of the entire surface of the valve, and the rows of varices in Sowerby's figure do not agree very strictly with other Neocomian examples of the same species. The only specimen with the test preserved figured by Agassiz is in an indifferent condition of preservation, the general figure resembles the typical form as exemplified by our specimen from the brown pisolite of Tealby, and also the variety

from Ventoux figured by D'Orbigny ('Pal. Fran.,' pl. 289, fig. 5), but the characters of the surface are obscure, and do not afford an adequate idea of the species.

The very characteristic figures given by D'Orbigny ('Paléont. Fran., Terr. Crét.,' Atlas,' tom. iii, plate 289, figs. 1—5) represent three Neocomian Trigoniæ of differing aspects, which are intended as illustrative figures of *T. rudis*, Park.; *T. nodosa*, Sow.; *T. spectabilis*, Sow.; *T. cincta*, Ag.; and *T. palmata*, Desh. The specimen figs. 1, 2 has affinities with certain ill-preserved examples of *T. nodosa*, from the coarse sandstone at Hythe, in the more horizontal direction of the rows of pallial varices, and in the great length of the siphonal border; two imperfect specimens in Mr. Sowerby's collection, mentioned by him in the 'Mineral Conchology,' now in the British Museum, illustrate these features; also our specimen from the lowest or Perna bed at Redcliff, Sandown Bay, excepting that the figure is more lengthened. Fig. 5, from Ventoux, has affinities with our Tealby specimen in the surface of the area and in the rows of small pallial varices with their rounded nodes, but differs in the ornamentation upon the position of the marginal carina; the *T. cincta* of Agassiz also approximates to the Ventoux variety. Figs. 3, 4 are strictly identical with the more common aspect of specimens from the beds of Crackers, Isle of Wight, which I have distinguished as *T. Orbignyana.* None of the figures present even a remote approximation to *T. spectabilis*, Sow., or to *T. palmata*, Desh. The former of these is the species next described; the latter is referred to as a variety of *T. dædalea;* neither of them occurs in the Neocomian formation.

Our variety *Orbignyana* is well exemplified by the shell figured for *T. dædalea* by Pictet and Renevier ('Foss. du Terr. Aptien de la Perte du Rhone,' plate 12, fig. 1), which offers no material difference when compared with the Atherfield specimens. Their example of *T. nodosa*, fig. 2 upon the same plate, differs so materially from all varieties of the species, whether British or foreign, that it cannot be accepted as pertaining to that species. The escutcheon in the present shell is so large, both in length and breadth, that when we find it furnished with a numerous series of regular transverse costellæ, which are visible even when the shell is laid upon its side, it is impossible to associate it with the narrow form, horizontal surface, and crowded, obliquely nodose varices which characterise the escutcheon in *T. nodosa;* the unusually lengthened form, the row of rounded nodes upon the whole length of the median carina, together with the short perpendicular rows of equal nodes upon the pallial portion of the valve, are equally distinctive; they also separate it from a large, imperfect, clavellated *Trigonia* figured by Pictet and Roux ('Grès Vert,' plate xxxv, fig. 5) for *T. nodosa*, in which the rounded nodes in the rows become symmetrically small and inconspicuous as they approach the area; they even pass across the area in an attenuated form. The general aspect of this species would associate it with the *Clavellatæ*, but as the limits of the area are not clearly defined, as it is without bounding carinæ, and as some of the rows of nodes pass across it, it should apparently be arranged with the *Quadratæ.* The escutcheon is not seen.

Foreign Localities.—The small examples of *T. nodosa* or *T. cincta* figured by

Agassiz are from blue Neocomian marls at Neuchatel. D'Orbigny records the occurrence of his *T. rudis* at Ventoux (Vaucluse); Morteau (Doubs); Saint Souveure (Yonne).

Trigonia spectabilis, *Sow.* Plate XXVI, figs. 1, 2, 3, 4.

Trigonia spectabilis, *Sow.* Min. Conch., vol. vi, tab. 544, p. 83, 1829.
— — *Pusch.* Polens Paläontol., p. 60, 1837.
— — *Agassiz.* Trigonies, p. 8, 1840.
— — *Morris.* Catal., p. 229, 1854.
— nodosa, *Pictet* et *Renevier.* Grès Vert, p. 484, pl. xxxv, fig. 5, 1857.

Shell subquadrate, short, depressed in the young state, thick and moderately convex when fully developed; umbones small, pointed, scarcely elevated above the superior border, of which they form the anteal extremity; the anterior border is truncated, it descends almost perpendicularly, but is curved at its junction with the lower border; hinge-border straight, forming nearly a right angle both with the anterior border and with the lengthened siphonal border. The surface of the area is equal to three sevenths of the entire valve; it is slightly convex, but depressed at the well-marked mesial junction of the two portions; the superior or more depressed half has a few unequal and imperfect rows of small nodes, or, in other instances, the few nodes are scattered irregularly; the other or inner portion of the area has at its umbonal extremity several subangular transverse ridges, which are continuations of those upon the other portion of the valve; each of these forms a prominent node at the position of the marginal and also of the median carina to the number of four or five rows, posteally to which the area has only a few irregular and obscure nodosities, which near to the siphonal border are effaced by plications of growth. The escutcheon is lengthened, very narrow, flattened, and inconspicuous; it is slightly overwrapped at its outer border by the nodosities of the inner carina of the area which are extended upon the escutcheon. The other portion of the shell has, mesially, four or five rows of very large, depressed, rounded varices; they become small and curved near to the pallial border, and enlarge considerably towards the angle of the valve; each row has about eight or nine large, depressed, ovate, and scarcely separated nodes, the longer diameter of these is across the varices; or the nodes are sometimes only obscurely defined or partially united in the rows; the first-formed four or five varices are entire, narrow, angulated, and transverse; their anteal extremities are bent upwards suddenly and perpendicularly; there is also an additional short varix adjoining the anteal extremity of the fourth row. The two last-formed rows of pallial varices are comparatively small, depressed, and cord-like; their general direction coincides with the lines of growth. In fully developed

specimens there is a space posteal to the varices which is occupied solely by prominent rugose folds of growth.

Internally the margins of the valves are smooth, excepting the pallial pits and eminences, which are small and only two or three in number. The prominences within the border of the escutcheon are also only two or three, and rather obscure. The cardinal teeth are large and diverge widely. All the specimens examined are single valves. The internal mould has not been ascertained.

Dimensions.—The largest example figured upon Plate XXVI is surpassed in size by specimens in both of the National Metropolitan Geological Museums; as, however, its condition of preservation is good, and as it sufficiently represents an advanced stage of growth, it may be accepted as a good illustration of the species. The length transversely is 25 lines; the height 34 lines; the length of the siphonal border and of the escutcheon are nearly equal, or 24 lines; the thickness through the single valve 5 lines. A smaller example has the length and height equal, but usually the length exceeds the height.

Comparisons.—No example of the *Quadratæ*, either British or foreign, appears to possess any near affinity with *T. spectabilis* in the combination of its few, simple, leading features, viz. the short, depressed, subquadrate figure, the few unusually large, nodose, unequal, but sometimes connected or cord-like pallial varices, together with the smaller and for the most part few and irregular nodes upon the expanded area. Our smallest figure, which illustrates the very young condition, is also well characterised by its high-ridged acute costæ and flattened form. Fully developed specimens have sometimes much rude irregularity in their surface ornaments. These occasionally altogether disappear, and the posteal half of the valve is then occupied solely by large rugose plications of growth. Our figures are truthful and characteristic, but do not fully exemplify these conditions, which may be better appreciated by examining the series of specimens upon the tablets in the British Museum. Pictet and Renevier, in their work above cited, have given a good figure of the present species under the designation of *T. nodosa;* no other author after Sowerby appears to have figured it. D'Orbigny united it to his *T. rudis*, together with *T. nodosa*, *T. cincta*, and *T. palmata* ('Pal. Fran., Terr. Crét.,' vol. iii, p. 137); but his illustrative figures represent Neocomian forms only, and are altogether distinct from *T. spectabilis.*

Stratigraphical position and Localities.—It is associated in the Greensand of Blackdown with the other *Trigoniæ* of those beds, but, owing to the fragility of the test, entire valves are rare. I am indebted to the liberality of Mr. Vicary, F.G.S., of Exeter, for the gift of specimens to illustrate *T. spectabilis* in the present Monograph; the species is well exemplified in both of the National Metropolitan Museums; more frequently private collections have it only in fragments.

TRIGONIA TEALBYENSIS, *Lyc.*, sp. nov.

A single very imperfect specimen in the Woodwardian Museum, Cambridge, is the only one known to me of a beautiful species of the *Quadratæ* obtained in the Neocomian formation at Tealby, Lincolnshire. Should no other more suitable specimen occur it is proposed to figure this fossil upon a future plate; unfortunately the shells in the bed of hard limestone at that locality are converted into fragile crystalline lime, which breaks into fragments by the concussion of a blow with a hammer; there is, therefore, little probability that any example devoid of injury will be obtained from that bed. In the present instance the posteal half of the valve has been broken away, and the figure of the shell longitudinally is, therefore, rather doubtful.

Diagnostic characters.—Shell short, inflated; umbones much arched inwards, slightly recurved, not prominent, obtuse; anterior side short, its border curved elliptically with the lower border; superior border convex. Escutcheon broad and flattened, its upper border elevated, its outer or carinal border depressed with closely arranged, narrow, diverging scabrous plications or rugose folds. Area narrow, flattened, forming a considerable angle with the other portion of the valve. The ornamentation of the umbonal portion of its surface is minute and delicate; there is a small median furrow; the marginal and inner carinæ are also very small and slightly knotted. The surface of the area has numerous regular, faintly defined, small, transverse indented lines. The other and by much the larger portion of the shell has the rows of nodose costæ numerous, concentric, and closely arranged; the nodes upon the rows are very numerous, small, perfectly regular, closely arranged, prominent, and only partially rounded, as if compressed laterally in the rows or moulded by the lines of growth, which are densely arranged and conspicuous over the anteal and middle portions of the valve; the rows have a slight horizontal flexure at their posteal extremities and also near to the anterior border, where their nodes become indistinct or cord-like. The fragment referred to has upwards of twenty rows of costæ, which do not represent the entire number. The convexity of the valve is very considerable; the faintly marked features upon the anteal portion of the area indicate that the posteal portion is altogether without ornamentation. The short, subglobose figure suggests the possibility that it may be identical with *T. paradoxa*, Ag. ('Trig.,' p. 46, tab. x, figs. 12, 13), known only from two internal moulds, which exhibit no trace of the external ornaments; in common with our shell they appear to have no near affinities with any one of the Cretaceous Trigoniæ; both are from the same formation. The French specimens of *T. paradoxa* are from the Neocomian of Besançon.

§ VI. Scabræ.

This, the predominating section of the genus in the Cretaceous rocks, is also special to them; the entire series has crenulated or scabrous costæ and costellæ; the area and escutcheon, devoid of bounding carinæ, are each limited by an angularity of the surface; the transverse costellæ of the escutcheon for the most part also pass across the area. It is decisively separated from all other sections by the position of the ligamental fissure, which is strictly inter-umbonal, so that in some species when the valves are united the ligament is concealed, or when the umbones are not closely placed the lengthened narrow fissure extends anteally to them.

In Britain the *Scabræ* form three sub-groups, which may be designated the *aliformis*, the *pennata*, and the *spinosa* groups. The first of these is remarkable for the prolonged and attenuated posteal extremity; the siphonal border is, therefore, very short; the incurrent orifice, the excurrent and anal orifices, were arranged near to each other, but separated by a short internal rib, as in other examples of the genus; in Britain its representatives are *T. aliformis*, *T. Vectiana*, *T. caudata*, *T. scabricola*, *T. Etheridgei*, *T. Meÿeri*, and *T. Fittoni;* there are also a numerous series of foreign analogous forms.

The second or *pennata* group has the attenuated posteal extremity of the first group; it is characterised by a feature which somewhat resembles the section of the *Glabræ;* it has an ante-carinal diagonal depressed space, which is either smooth or has a faintly defined series of perpendicular costæ. *T. pennata* and *T. sulcataria* are the only British species; two other species occur in France.

The third or *spinosa* group has the borders of the valves comparatively short and rounded. The pallial costæ and costellæ of the area and escutcheon diverge from the angle of the valve. *T. spinosa*, *T. ornata*, *T. Archiaciana*, *T. Agassizii*, *T. Vicaryana*, and *T. Cunningtoni* are its British representatives. The foreign analogues of this group are even more numerous.

A fourth group, which does not appear to be represented in Britain, is characterised by possessing the usual ornamented escutcheon of the *Scabræ* together with the area of the *Clavellatæ*, with their bounding carinæ and delicate transverse plications; the pallial costæ are extremely variable. *T. Lusitanica*, Sharpe, *T. elegans*, Baily, and *T. Constantii*, D'Orbigny, may be referred to this group.

TRIGONIA ALIFORMIS, *Park.* Plate XXV, figs. 3, 3 *a*, 4, 4 *a*, 5, 6.

TRIGONIA ALIFORMIS, *Parkinson.* Org. Remains, vol. iii, p. 176, tab. xii, fig. 9, 1811.
— ALÆFORMIS, *Sowerby.* Mineral Conchology, vol. iii, tab. 215, 1818.
— ALIFORMIS, *Deshayes.* Coq. car., p. 33, tab. x, figs. 6, 7, 1831.
LYRIODON ALÆFORME, *Bronn.* Leth. Geog., vol. ii, p. 700, tab. xxxii, fig. 15, 1837-8.
TRIGONIA ALÆFORMIS, *Pusch.* Polens Paläontologie, p. 60, 1837.
— ALIFORMIS, *Fitton.* Quart. Journ. Geol. Soc., vol. iii, p. 289 (pars), 1843.
— — *Agassiz.* Trigonies, p. 31, tab. vii, figs. 14—16, tab. viii, fig. 12, 1840.
— ALÆFORMIS, *Morris.* Catalogue, 2nd ed., p. 228 (pars), 1854; exclude L. G. S. of Sandgate and Boughton.
— ALIFORMIS, *Pictet.* Paléont. Suisse, tom. i, pl. xiv, fig. 1, 1857; exclude fig. 2.

Exclude the following figures of *Trigoniæ* named *T. aliformis:*

Leopold de Buch, Petrefacta recuillies en Amerique, par A. de Humboldt et par Ch. Degenhardt, fig. 10, 1839.
Forbes, Geol. Trans., 2 ser., vol. vii, part iii, p. 151, 1846.
D'Orbigny, Pal. Fran., Terr. Crét., vol. iii, p. 143, pl. 291, figs. 1—3.
Lyroden aliforme, Goldfuss, Petref., vol. ii, tab. 137, fig. 6, 1836.
Pictet and Roux, Grès Vert, pl. xxxv, figs. 2 *a*, *b*, 1847-53.
Pictet and Renevier, Terr. Aptien de la Perte du Rhône, pl. xiv, fig. 2, 1857. (Fig. 1 is from a Blackdown specimen.)

Trigonia aliformis is placed at the head of the first group; it is characterised as follows:

Shell sublunate, inflated anteally, produced, attenuated and depressed posteally; umbones much elevated, antero-mesial, pointed, much recurved and incurved; anterior side produced, its border rounded; lower border rounded, but somewhat excavated posteally; hinge-border lengthened, concave, terminating posteally in a rostrated and attenuated extremity; ligamental aperture narrow, inter-umbonal. Escutcheon lengthened, deeply concave, occupying the entire upper surface of the shell; its superior or inner border is plain and much raised; its outer border is formed by a narrow, elevated, and rounded area; it is traversed transversely or obliquely by numerous closely arranged, small, serrated costellæ, which are prominent near to the umbones, but become only faintly traced posteally. The area is very narrow, raised, and convex; it is rendered bipartite throughout its entire length by a deep groove and its superior or umbonal portion has a few small, ridge-like, transverse costellæ; the remainder of its length has small, irregular, transverse plications.

The other portion of the surface has a numerous series of costæ, which originate at

the border of the area as narrow, rounded, crenulated ridges, and diverge in every direction; about seven costæ nearest to the apex are concentric or are curved obliquely; the next succeeding seven, or more, enlarge or become inflated at their middle portions, and pass obliquely downwards to the pallial border; their crenulations are faintly traced and irregular, forming obtuse, transverse nodes upon the costæ, which become attenuated as they approach the pallial border. The more numerous and smaller costæ occupy the more flattened or posteal portion of the shell; they are small, narrow, rounded, very closely arranged, minutely crenulated, and nearly perpendicular; their extremities render the lower border dentated. The middle or inflated costæ form a slight undulation approaching to a falciform flexure; the interstitial spaces are plain. The narrow posteal portion of the shell, with its closely placed perpendicular costæ and depressed surface, contrasts strongly with the inflated anteal surface with its more widely separated costæ enlarged mesially and attenuated at their extremities. Usually specimens of adult growth have upon the anteal face of the valve and adjacent to the borders numerous small, rather obscure, horizontal ridges, or supplementary costellæ, which occupy the intercostal spaces of the first-formed six or seven costæ, a feature which is only visible in well-preserved specimens. The change from the inflated anteal surface to the depressed and flattened posteal portion is abrupt and strongly characterises the species.

The inner borders of the valves are dentated by the extremities of the pallial costæ; the narrow flattened surface forming the inner border of the escutcheon has a numerous series of small transverse pits; the narrow produced siphonal border is gaping, and contracted mesially by a projecting longitudinal internal rib in each valve placed beneath the mesial furrow of the area and serving to separate the incurrent and excurrent orifices; the other borders of the valves are close fitting.

Dimensions of an unusually fine specimen in the collection of Mr. Vicary and intended to be figured upon a future plate:—Length of the angle of the valve 27 lines; length from the pedal border to the siphonal border 26 lines; height 21 lines; diameter anteally through the united valves 14 lines; breadth across the area and escutcheon 9 lines; length of the siphonal border 5 lines.

T. aliformis also occurs as a distinct variety and in some abundance in the highest Greensands of Wiltshire at Warminster, and of the Isle of Wight at Ventnor; the fossils are invariably deprived of their tests, and are usually flattened from vertical pressure. Two uncompressed specimens are represented (Plate XXV, figs. 5, 6); the surface ornaments are sufficiently distinct excepting upon the area and escutcheon, where they do not appear to differ materially from the corresponding portions of the typical form. Compared with the latter, the figure is more produced and attenuated posteally and less inflated anteally; the change from the small posteal perpendicular costæ to the larger, curved, middle series is much less abrupt, and, as the umbones are less recurved, they are more erect, and are nearer to the anterior side, which is shorter; the escutcheon is also more lengthened. Possessing these differences, which are well

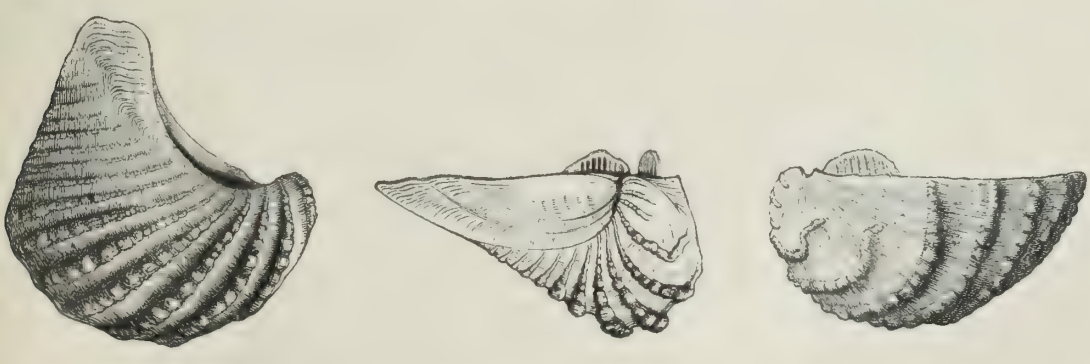
exemplified by our figures, it is, perhaps, doubtful whether the variety from the Chloritic Marls and Sands should be named *aliformis*. The question has engaged my attention fully, aided by the comparison of ample materials. The typical form of the Blackdown and Haldon Greensand is remarkably exempt from any considerable amount of variability, so that, whatever may be the number of specimens or their stages of growth, no question can ever arise respecting their identity as a species. With the presumed variety the conditions are altogether different; deprived of the test, the most reliable means of comparison does not exist. The Warminster specimens are not only ill preserved, but they are invariably flattened and sometimes distorted by vertical pressure. Such appears to be the case with all the specimens collected by Mr. Cunnington, who kindly forwarded to me an unusually numerous series for comparison. A varied series of specimens from a similar stratigraphical position near Ventnor affords a nearly similar result, excepting that the fossils, having been enveloped in a finer sediment, have their surfaces occasionally better preserved, and have sometimes, but rarely, escaped compression. With such selected specimens, however, occur numerous others, flattened, but appearing to possess the usual attributes of the typical form in a degree sufficiently marked to prevent them from being assigned to a distinct variety. Having due regard, therefore, to the much higher position of the presumed variety, I propose to regard it as such, and to distinguish it by the name *attenuata*. The typical form is somewhat abundant in the lower beds of the Blackdown and Haldon Greensand, associated with a still more common species of the same group, *T. scabricola*. It has also been tabulated in lists of Lower Greensand fossils by Ibbetson and Forbes, by Fitton, by Mantell, and by Morris. A few badly preserved examples representing fossils of the same group, obtained in the Lower Greensand at the Isle of Wight, in the Kentish beds, and also near Cambridge, have been brought under my notice; for these and for similar examples from France the reader is referred to the next species, *T. Vectiana*.

History, and Comparisons with allied forms of the Scabræ.—The figures of *T. aliformis* given by Parkinson ('Org. Rem.,' vol. iii, pl. xii, fig. 9) and by Sowerby ('Min. Conch.,' vol. iii, pl. 215) are excellent representations of the typical form from the Greensand (Whetstone pits) of the Blackdown district. During some years subsequently, Continental cultivators of palæontology, in the absence of the means of comparison which are now possessed, assigned to Parkinson's species several allied forms of *Trigonia* from various localities and stratigraphical positions. The general absence of sufficiently definite descriptions of the several features which characterise the *Trigoniæ Scabræ*, in these and other authors, has induced me to omit notice of such descriptions when they are not accompanied by illustrative figures, unless they are in other respects sufficiently verified. As *T. aliformis* has been believed to occur at various localities in each of the four continents, the comparisons, in some instances referring to figures of fossils, the originals of which are unknown to me, require much critical care in estimating them.

The figure and brief description of *Trigonia thoracica*, Morton ('Synopsis Org. Rem. of the Calcareous Group of Alabama, United States,' p. 65, pl. xv, fig. 13, 1834),

assigned by Von Buch to the *T. aliformis* of Parkinson, fails in all the characteristic features of that species. It appears to be allied to, and perhaps is not really distinct from, a large Bogota species figured by Von Buch for *T. aliformis* ('Description des Pétrifications recueillies en Amerique, par Alex. de Humboldt et par Ch. Degenhardt,' 1839, fig. 10). The figures of these American allies of *T. aliformis* are indicative of an indifferent condition of preservation, which should induce us to distrust the value of any theoretical conclusions founded upon such materials. It would appear also from the general tenor of Von Buch's remarks in his memoir on the characteristic fossils of the Cretaceous rocks ('Betrachtungen über die Verbreitung und die Grenzen der Kreide-Bildungen,' 1849) that he was even inclined to arrange all the lengthened forms of the *Scabræ* as a single species, or, in other words, to refer them all to *T. aliformis;* he also records his astonishment at its great and perhaps unexampled geographical range; that it occurs in the State of Alabama, in the mountain-ranges of Central America, again in the mountains of Santa Fe de Bogota, South America. He even unites to *T. aliformis* the *T. ventricosa* of Krauss from Algoa Bay, South Africa; and remarks that it is found, as if blown by the winds over the vast peninsula of Hindostan, in the south-west, near Pondicherry. The examination which I have instituted leads me to reject altogether a statement so general and unexampled; the figure of *T. thoracica,* Morton, which Von Buch referred to *T. aliformis,* and also the large Bogota shell, to which he gave the same name, have the general figure short posteally, without attenuation. The costæ are also different in figure; the areas and escutcheons are not delineated; they cannot, therefore, bear a strict comparison with any known European species.

T. ventricosa, Krauss ('Nova Acta Acad. C. L.-C. Nat. Cur.,' vol. xxii, part 2, p. 456, tab. xlix, fig. 2, 1850), is so important a fossil, from its wide distribution in South Africa and its great numbers, and from its having been united by Von Buch to *T. aliformis,* and very inadequately figured by Krauss, that I have been induced to subjoin the following figures taken from a specimen in the British Museum, which possesses a remarkably fine and numerous series numbered 49,990. The locality is Sunday's River, District of Uitenhage, South Africa, at a place named Prince Alfred's Rest.[1]



Three views of the valves of *Trigonia ventricosa,* Krauss, from South Africa.

[1] See 'Quart. Journ. Geol. Soc.,' vol. xxvii, p. 500, &c.

Larger than *T. aliformis,* it is so much inflated anteally that the diameter through the united valves is equal to their height and greater than their length in adult specimens; the umbones are remarkably large and arched inwards. The anteal varices (about ten) are large, oblique or almost perpendicular, each fringed with a row of depressed, oblong, or sometimes ovate nodes. The posteal varices (about eight) are small, narrow, closely arranged, and perpendicular; the area is convex, plain, and bipartite; the escutcheon is very wide and boat shaped, with a few transverse costellæ. It occurs very abundantly at several localities on the Sunday's and Zwartkop Rivers, associated with a considerable fauna, including the two gigantic species of *Trigonia, T. Herzogii,* Haussman, and *T. conocardiformis,* Krauss, which are also exceedingly abundant. The former of these is well known from the excellent figure of it in the great work of Goldfuss ('Petref.,' tab. 137, fig. 5); of this the British Museum has an unusually fine series of specimens numbered 46,461.

More recently, a considerable number of fossils from South Africa having been added to the rich collection in the Museum of the Geological Society, Mr. R. Tate communicated a memoir descriptive of them and of their distribution ('Quarterly Journal Geological Society,' vol. xxiii, part 3, p. 139, 1867). The comparison of these African forms with their supposed European analogues has led to his assigning them to the Lower Oolitic rocks, but with the reserve which should always qualify conclusions deduced from comparisons of fossils so remote geographically. Admitting the general apparent Jurassic *facies* of certain fossils figured in the plates illustrating Mr. Tate's memoir, I am nevertheless much impressed by the presence in such considerable numbers of *Trigonia Herzogii* and *T. ventricosa,* the former an elongate example of the *Quadratæ,* the latter of the *Scabræ,* sectional forms which in Europe, Asia, and America, are special to and eminently characterise the Cretaceous rocks. *T. ventricosa* more especially is nearly allied to, and possibly is not really distinct as a species from, *T. tuberculifera,* Stol., from the Cretaceous rocks of Southern India ('Mem. Geol. Survey of India,' vol. iii, pl. xv, figs. 10—15, p. 335). A comparison of these figures of Dr. Stolicza with the very numerous specimens of *T. ventricosa* in the British Museum indicates even a closer affinity than would be looked for, judging from the single specimen of the latter the subject of our wood-engraving; the nodes upon the larger varices occasionally have all the roundness and distinctness which characterise the Indian species.

Another form allied to *T. ventricosa* is a short inflated shell, *T. Delafossei,* Leymerie, from the Cretaceous rocks of Spain ("Mém. sur un nov. type Pyrénéen," 'Mém. Soc. Géol. de France,' 2 sér., tom. iv, pl. viii, fig. 27). This latter form is even shorter and more inflated than the South African fossil; its anteal or larger varices are each fringed with a row of separate rounded tubercles; their direction is more oblique than in *T. ventricosa.* The other gigantic *Trigonia* associated with *T. Herzogii* in Southern Africa is *T. conocardiformis,* Krauss, inadequately represented in the reduced figures given by that

author in the 'Nova Acta,' above quoted; it is an abnormal, depressed, and altogether very peculiar example of the *Clavellatæ*, and is only very remotely allied to any other known species of that section. Its general aspect has some resemblance to a lengthened *Pholadomya;* its hinge characters are well exposed, otherwise it might be mistaken for another genus. The *Clavellatæ*, although eminently Jurassic, are not exclusively so, as the section is represented in British Neocomian rocks by two species.

The supposed presence of *T. aliformis* in the Cretaceous rocks of India referred to by Von Buch is founded upon a memoir by Professor E. Forbes on Cretaceous fossils from the hill of Verdachellum, south-west of Pondicherry ('Geol. Trans.,' 2nd series, vol. vii, part 3, p. 151). The liberality of the Geological Society in granting to me the loan of the *Trigoniæ* from Verdachellum upon which the observations were grounded has enabled me to compare them carefully with British species; the results are as follow:—

Six specimens representing species named *T. semiculta*, *T. suborbicularis*, and *T. orientalis*, are examples of the *Glabræ*, and differ from any known European forms; apparently the two latter species should be merged in one; they are sufficiently figured in the plates which accompany the memoir.

The Indian supposed representative of *T. aliformis* is founded upon a single small example of the *Scabræ*, which, when perfect, would be about 12 lines in length, but the posteal portion is broken away, which reduces the length to $9\frac{1}{2}$ lines, in a matrix of reddish-brown, concretionary rock. A delicate valve of a small *Placunopsis* lies across the area and escutcheon, the surfaces of which, however, are not obscured by the parasitic valve. A mere first glance is sufficient to assure us that the comparison could not have been made with any British example of *T. aliformis*, and that the Indian species cannot even be arranged as a variety of that form. The figure not less than the ornamentation is distinct; it has nothing of the posteal flattening and sudden anteal inflation which is so characteristic of Parkinson's species, no separation of the costæ into two kinds, viz. the small, perpendicular posteal, contrasted with the oblique anteal, inflated mesially, with their delicate, almost evanescent crenulations. On the contrary, the contour of the surface is uniform, and the costæ are all of one kind, narrow, elevated, and straight for the most part, but having a few of the first-formed curved towards the anterior border; all are fringed with large, obtuse, prominent, irregular, and unequal nodes, but the few first-formed or umbonal rows have the little nodes or tubercles regular and bead-like; all are united to the angle of the valve, which forms a distinct, narrow-knotted ridge. The area and escutcheon are together large and concave; the area, much wider than in any British species of the *aliformis* group, has transverse costellæ conformable in number with the costæ; they are large and suddenly form a row of prominent narrow varices, which separate the area from the more depressed and concave escutcheon, across which the costellæ also pass in a more attenuated form. The whole of these features differ essentially from the corresponding parts in *T. aliformis;* and the border of elevated

narrow varices separating the area and escutcheon form also a prominent distinguishing feature.

Rejecting the comparison with *T. aliformis* as presenting only remote affinities, there remains the possibility that *T. Vectiana* of the Neocomian beds (which has been confounded with *T. aliformis*) may possibly have formed the subject of comparison. As the Indian species of Forbes appears to have been unknown to the Geological Survey of India, being absent in the Cretaceous species described by Dr. Stolickza, I have been induced to give the following engravings of it, magnified one diameter.

Trigonia Forbesii, Lycett, from Verdachellum, India.

It will be perceived that the general figure differs from *T. Vectiana* so considerably that their identity as a species is quite precluded.

D'Orbigny assigns an American species named *aliformis* to his *T. limbata* ('Prodr. de Paléont.,' vol. ii, p. 240, No. 592), and also the Indian species of Forbes. To separate the latter from the species of D'Orbigny it is only necessary to direct attention to the narrow, almost linear area, the produced anterior side, and the curved costæ of *T. limbata*, as depicted in the figures given by D'Orbigny.

T. aliformis, D'Orbigny ('Pal. Fran.,' p. 143, pl. 291, figs. 1—3) is distinct from the British species; the apices are less elevated and more anterior; the shell is more produced posteally, having a distinct, plain area, which extends even to the apex; the costæ are crossed by a few widely separated sulcations; they enlarge towards the pallial border throughout all the rows; they also appear to be destitute of crenulations.

The *Lyrodon aliforme* of Goldfuss ('Petref.,' tab. 137, fig. 6, vol. ii) also differs essentially from Parkinson's species in the general figure and the ornamentation of both portions of the shell. The escutcheon has prominent transverse costellæ over its entire length, and the other surface of the valve has the costæ radiating equally and fringed with closely set, regular, small, bead-like tubercles.

The *Trigonia aliformis* of Pictet and Roux ('Grès Vert,' pl. xxxv, figs. 2 *a*, *b*) apparently does not differ materially from the species figured by Goldfuss.

The *Trigonia aliformis* of Pictet and Renevier ('Terr. Aptien de la Perte du Rhone,' pl. xiv, figs. 1 and 2) :—Fig. 1 is a Blackdown example; fig. 2, from the Rhone, is *T. Vectiana*, to which the reader is referred.

T. aliformis, Agassiz, 'Trigonies,' tab. vii, figs. 14—16; also tab. viii, fig. 12, both represent British specimens.

In fine, it results from the foregoing comparisons of analogous forms, that I have been unable to discover any example of *Trigonia aliformis* obtained at any foreign locality; also that the few figures given by foreign authors, which are correctly attributed to that species are delineations of British specimens.

TRIGONIA VECTIANA, *Lyc.* Plate XXIV, figs. 10, 10 *a*, 10 *b*, 11; Plate XXV, fig. 7.

TRIGONIA ALÆFORMIS, *Mantell.* Geology of Sussex, p. 73, No. 11, 1822.
— ? PLICATA, *Agassiz.* Trigonies, p. 33, pl. x, fig. 11, 1840. (Specimen deprived of the test.)
— ALIFORMIS, *Ibbetson* and *Forbes.* Proc. Geol. Soc., vol. iv, part ii, Table to face p. 414, 1844. (Fossils of the Perna Band.)
— ALÆFORMIS, *Fitton.* Stratigraphical section from Atherfield to Black Gang Chine; Table opposite p. 289 (fossil No. 64, bed No. 45), Quart. Journ. Geol. Soc., vol. iii, No. 11, 1847.
— ALIFORMIS, *Pictet* et *Renevier.* Foss. du terr. Aptien de la perte du Rhone, et des Env. de St. Croix, 1857, pl. xiv, fig. 2 *a*, *b c*; exclude fig. 1, which is a Blackdown specimen of *T. aliformis.*
— — *Judd.* On the Punfield Formation, Quart. Journ. Geol. Soc., p. 220, 1871.

One of the *Scabræ* allied to *T. aliformis*, and possessing a considerable general resemblance to that species; it has been mistaken for it by several palæontologists—by Mantell, by Fitton, also by Ibbetson and Forbes, and more recently by Pictet and Renevier. In addition to possessing well-marked palæontological distinctive features, it is also separated from the other species by its stratigraphical position, which is limited to the Neocomian formation. Its diagnostic features are as follows:—Umbones considerably incurved and recurved, or not erect; the middle and anteal portions of the valves are without that sudden inflation which in *T. aliformis* contrasts so strongly with the abrupt flattening of the attenuated portion of the valve posteal to it; the costæ or varices diverge symmetrically from the angle of the valve with great regularity obliquely downwards, with a slight sinuation towards the angle of the valve and regular curvature; the summits and sides of the costæ are strongly, closely, and regularly crenulated; they therefore form a well-marked contrast to the faintly marked and unequal crenulations of *T. aliformis*, which are also limited to the summits of the costæ. The escutcheon possesses features equally distinctive; it has throughout its length a

series of regular, transverse, strongly defined costellæ, which also pass across the narrow area to the divisional angle of the valve in specimens of immature growth, but in fully developed examples the posteal portion of the area is destitute of costellæ. The area and escutcheon together form a wider surface than in *T. aliformis;* the escutcheon is less distinctly bounded, its costellæ are smaller and somewhat more numerous than the costæ upon the other portion of the valve; the separation of the two portions of the surface at the angle of the valve is clearly defined, and for the most part forms a narrow divisional ridge, from the sides of which both costæ and costellæ diverge with great regularity. These features, and more especially the transverse ridges or costellæ upon the escutcheon throughout its length, afford a strong contrast to the delicate or evanescent surface-ornaments upon that portion of *T. aliformis.*

It may be mentioned, as affording an explanation of the supposed identity with *T. aliformis*, that well-preserved specimens of *T. Vectiana* in the Perna-bed at Atherfield are rare, and that the moulds of external casts at Black Gang Chine would readily be mistaken for *T. aliformis* without a careful comparison of the escutcheon in each instance.

A small example of the *Scabræ*, figured by Agassiz ('Trigonies,' p. 33, pl. x, fig. 11) under the name of *T. plicata*, appears to be nearly allied to, and may be identical with, *T. Vectiana;* but, as it is founded upon a single specimen only, and deprived of the test, it is not possible to make any satisfactory comparison with it; apparently the crenulated costæ are somewhat more numerous than in the British species. Agassiz believed that his specimen was obtained in the Portland formation (zone of the Calcaire à Ptérocères) in the environs of Besançon. My whole experience is opposed to this conclusion, neither does there appear any reason to doubt that it was obtained from the Cretaceous rocks.

The Indian *T. Forbesii*, described and figured with *T. aliformis*, has the general figure more ventricose, so that the area and escutcheon have greater breadth, the posteal portion of the shell is scarcely attenuated, the umbones are much less elevated, the costæ are without curvature, fringed with a few nodes, and are without the delicate, closely set crenulations, both upon their summits and sides, which characterise *T. Vectiana.*

The *T. aliformis* of Pictet and Renevier from the "Terrain aptien" of the South of France, above cited, represents a finely preserved example of *T. Vectiana*, much exceeding the size of specimens occurring in the Perna-bed at Atherfield, the dimensions of which are fairly represented by our figures; these are of not fully developed growth. The other figure of *T. aliformis* in the work of Renevier is an undoubted Blackdown specimen of that species.

Stratigraphical positions and Localities.—*T. Vectiana* occurs somewhat rarely in the lowest, or Perna, bed stratum of the Neocomian formation at Atherfield, Isle of Wight. At Black Gang Chine, in the same vicinity, its moulds and casts occur abundantly

in ferruginous concretionary masses derived from the bed No. 45 of Dr. Fitton's elaborate and valuable stratigraphical Table above referred to; the position of this bed is nearly at the upper boundary of the Neocomian formation. Another locality is Seend, near Devizes, in a similar stratigraphical position.

Trigonia Meyeri, *Lyc.*, sp. nov. Plate XXIII, fig. 6.

Shell ovately trigonal, very convex anteally, attenuated and compressed posteally; umbones large, elevated, antero-mesial, pointed, much recurved; anterior side produced, its border rounded and curved with the lower border, which becomes nearly straight posteally near to the attenuated extremity; the superior border is much excavated and lengthened, terminating posteally abruptly, forming nearly a right angle with the siphonal border, which is nearly perpendicular, its height scarcely exceeding one fourth the height of the valves. The area is narrow, much curved, slightly elevated, separated from the other or pallial portion of the valve by a distinct narrow divisional angle or slight ridge; this does not rise higher than the surface of the area, which is delicately transversely lineated over its posteal half, and traversed by a distinct longitudinal mesial furrow; the anteal portion of the area is traversed transversely by a numerous series of small, closely arranged, wrinkled costellæ, which pass also without interruption across the larger escutcheon. The upper surface of the valve is almost entirely occupied by a large, concave escutcheon, which is conspicuously costellated transversely throughout its length; its breadth exceeds that of the area, from which it is separated only by a faintly elevated ridge. The larger or pallial portion of the valve has a series of about twenty-six rows of small, closely placed, rounded, and slightly crenulated costæ, all of which originate at the carinal angle of the valve and pass downwards nearly perpendicularly; the more posteal ten rows occupy the more flattened or depressed portion of the surface, they enlarge slightly near to the lower border; the other or more anteal rows form a sudden flexure about their middle portions, where they also enlarge as suddenly and pass forwards almost horizontally to the anterior border, becoming somewhat curved and attenuated at their anteal extremities. The anteal or pedal border has upon its upper half a closely set series of small, oblique, supplementary costellæ, two of which occupy each of the intercostal spaces to the number of nine spaces.

This is one of the more inflated of the *aliformis* group, the great convexity, as in that species, being limited to the anteal third of the shell; the sudden flexure of the costæ at that part and their attenuation upwards to the angle of the valve are very conspicuous features and distinguish it from all others of the *Scabræ*, including *T. aliformis*, which, with fewer costæ, has also a smaller flexure and much less abrupt; the anteal varices are also much fewer, more oblique, and more inflated.

Affinities, and Stratigraphical position.—The first few specimens examined were very imperfectly preserved; they were obtained by Mr. C. J. A. Meyer in beds of Chloritic Marl and Greensand at Dunscomb Cliffs, to the eastward of Sidmouth, and were at first regarded as dwarfed representatives of *T. abrupta*, Von Buch, figured by Coquand ('Monogr. de l'Étage Aptien de l'Espagne,' pl. xiii, figs. 4, 5), apparently from a large and fine specimen, nearly three inches in length and more than half that measurement through the united valves; it is, therefore, two and a half times larger in linear dimensions than British examples of its analogue; it also presents some differences in figure; its umbones are much more nearly erect, the anterior border is less rounded, the outline of the siphonal border is much more oblique and less short; the contrast between the anteal, horizontal, inflated costæ, and the posteal, smaller, and perpendicular ones, is much less conspicuous; but, perhaps, the most marked distinction consists in the absence of the numerous transverse costellæ upon the anteal half of the area. As the Spanish specimen is from the Aptian beds, we should scarcely expect to find identity of species in fauna so widely separated, both geographically and stratigraphically. The drawing of *T. abrupta*, Von Buch ('Pétref. recueil. en Amer. par Alex. de Humboldt et par Ch. Degenhardt,' fig. 21), to which Coquand referred his specimen, is defective in the several details which are necessary to enable us to characterise Cretaceous *Trigoniæ;* the general figure also differs so decidedly from all known European examples that, in the absence of M. Coquand's monograph I should not have ventured to allude to the South-American fossil as a form nearly allied to that in the higher beds of the Sidmouth Upper Greensand. The subovate outline especially differs; the shell appears to be without the anteal inflation and posteal attenuation common to several species of the *aliformis* group; the umbones without elevation or curvature, the straightness of the divisional angle of the valve, the absence of all character upon the area and escutcheon, and even the drawing of the costæ upon the side of the valve, cannot be accepted as delineations of the European Aptian form, and still less of the smaller British species; the curvature of the anteal costæ has little of the angularity and abruptness upon which the name is founded. The name was probably retained by Coquand in the belief that the American specimen figured by Von Buch is very defective in the several features above mentioned, and that the species is probably identical with the Spanish Aptian Trigonia. Another interesting South-American Trigonia figured by Von Buch is *T. Humboldtii*, figs. 29, 30, which has costæ radiating from the umbo over the greater portion of the surface; it has affinities with *T. divaricata*, D'Orbigny, and tends to connect the Cretaceous *Scabræ* with the living Australian section, the *Pectinidæ*.

At several localities near Sidmouth our species is associated with *T. læviuscula*, *T. sulcataria*, *T. pennata*, and *T. Vicaryana;* it occurs only within a very limited vertical range; several better preserved specimens, including the original of the figure (Plate XXIII, fig. 6), have proved its distinctness from the Aptian form. Other specimens from Chardstock are in the Museum of the Royal School of Mines; only

single valves have been obtained. The internal mould is not known. Dimensions of the specimen figured.—Length 16 lines; height 13 lines; thickness through a single valve 5 lines.

Named after Mr. C. J. A. Meyer, F.G.S., whose researches in the Cretaceous rocks of the southern counties of England have contributed materially to a more exact knowledge of the Greensand formations, and of their relations to similar deposits elsewhere.

Trigonia Etheridgei, *Lyc.*, sp. nov. Plate XXVII, figs. 1, 1 *a*, 1 *b*, 2, 3, 3 *a*.

Trigonia caudata, *Ibbetson* and *Forbes*. Table showing distribution of Lower Greensand Fossils in the Isle of Wight, Bed No. 3 (exclude Upper Greensand), Proc. Geol. Soc., vol. iv, No. 101, p. 414, 1844.

— — *Fitton*. Stratigraphical section from Atherfield Point to Black Gang Chine (Beds 1, 2; Fossil 63). Quart. Journ. Geol. Soc., vol. iii, No. 11, p. 289, 1847.

Shell sublunate, much inflated, compressed upon the anterior face, which is very wide; umbones much elevated, erect, very large, much incurved and recurved, their apices are slightly separated when the valves are close; their recurvature is so considerable that the ligamental fissure is seen anterior to them (Plate XXVII, fig. 1 *a*, 1 *b*); the anterior border is very short and truncated, slightly curved with the lower border, which is nearly straight, and both borders are nearly of equal length; the upper border is much excavated, its posteal extremity terminating abruptly at the produced posteal portion of the valve. The escutcheon is unusually large and deeply excavated, its superior or inner border is slightly raised, it is traversed transversely by ten or eleven narrow, widely separated, slightly serrated costellæ; the outer border is elevated and rounded; its posteal portion is rendered bipartite by a well-marked mesial furrow, constituting a very narrow and distinct area; near to its caudal extremity are some transverse irregular plications. The fully developed shell has upon its sides about seventeen narrow, elevated, ridged costæ; they occur at regular distances and are very widely separated; about nine costæ originate at the anterior border and curve slightly outwards to the flexure of the valve, thence they are suddenly directed obliquely upwards to the area; the four lower costeal ridges of this anteal series are more than usually elevated at their middle portions or at the flexure of the valves, where they become broad and projecting, each forming a kind of lobe and having two or three rounded, irregular nodosities; the succeeding more posteal costæ (eight in number) are smaller, acute, narrow, and high-ridged, passing perpendicularly downwards to the lower border;

all the costæ are more or less slightly crenulated, the posteal series have their edges acute, rough, and irregularly scabrous; their lower extremities alternate at the border with those of the other valve, producing a peculiarly jagged outline. Upon well-preserved examples the anterior face of the valves discloses a considerable number of minutely knotted radiating lines, which cross the wide intercostal spaces and become evanescent near the lower curvature of the valves; they appear to be irregular in their distribution and remind us of the surfaces of the Arcas. The less wide interstitial spaces of the posteal costæ have occasionally each a single mesial perpendicular line, but more frequently these are evanescent. The escutcheon also exhibits some traces of radiating lines similar to those upon the anteal face of the shell. Young specimens do not differ from adult forms in any material degree; they are, therefore, equally distinctive when compared with contemporaneous species.

This large and remarkable species of the *Scabræ* has been mistaken for *T. caudata*, and tabulated as such in lists of Isle of Wight fossils. Compared with *T. caudata*, our species is much larger, the umbones are much more elevated and larger, the anterior side is more short and flattened, the caudal extremity is shorter; the upper border of the escutcheon is much more concave or depressed, its costellæ do not form fringing prominences as in *T. caudata;* the costæ are narrower, more elevated and acute; they are destitute of obtuse, crenulated, fringing outer borders; the presence of the inflated lobes at the anteal flexure of the valves upon four of the costæ, and of radiating knotted lines upon the anterior flattened surface, gives also distinctive features. The peculiarly narrow and scarcely defined area, destitute of distinct costellæ, also affords a contrast to the prominent area and its well-marked costellæ in *T. caudata.* From *T. aliformis* it is distinguished by the few, widely separated, acute, perpendicular posteal costæ, by the absence of the sudden inflation which characterises the anteal half of the valves, by the wide, compressed anteal surface, by the greater breadth of the united valves, and by the few large strictly transverse costellæ upon the escutcheon, contrasted with the very numerous, delicate, oblique, and almost evanescent costellæ of *T. aliformis*; generally, also, by the wide intercostal spaces and by the radiating knotted lines upon the flattened anterior surface in well-preserved specimens. The lower border is also remarkably distinct. *T. aliformis* has the extremities of the perpendicular costæ upon each valve, corresponding each to that of the opposite valve. In *T. Etheridgei* they alternate, thus producing a peculiarly jagged outline at the border.

Dimensions of an adult specimen.—Height $2\frac{1}{2}$ inches; length, horizontally, 3 inches; diameter through the united valves anteally, $2\frac{1}{2}$ inches.

Stratigraphical position and Localities.—In the Isle of Wight it occurs only in the lowest or *Perna Mulleti* beds of the Atherfield clay. The valves are usually united, and, owing to the large size and inflated figure, it is one of the most remarkable species of that peculiarly rich assemblage of Neocomian fossils. The test is thick, and specimens are usually well preserved; it occurs in some abundance. It will be observed that this is a

lower geological position than pertains to *T. caudata*. The name is intended as a trifling recognition of valuable and cordial assistance and information rendered to the author by Mr. Etheridge, F.R.S., and of the interest which he has uniformly taken in the progress of this Monograph.

Trigonia caudata, *Ag.* Plate XXVI, figs. 5, 6, 6 *a*, 6 *b*, 7.

Trigonia caudata, *Agassiz*. Trigonies, p. 32, tab. vii, figs. 1—3, 11—13, 1840.
— — *D'Orbigny*. Pal. Fran., Terr. Crét., vol. iii, p. 133, pl. 187, 1843.
— — *Forbes*. Quart. Journ. Geol. Soc., vol. i, p. 244, 1845.
— — *Marcou*. Jura Salinois, p. 142, 1846.
— — *Fitton*. Strata at Atherfield, Journ. Geol. Soc., vol iii, No. 11, p. 313, 1847.
— — *D'Orbigny*. Prodrome de Paléont., vol. ii, p. 78, 1850.
— — *Buvignier*. Statist. géol. minéral. et paléont. de la Meuse, p. 473, 1853,
— — *Studer*. Geol. du Schweiz, vol. ii, p. 281, 1853.
— — *Morris*. Catal., p. 228, 1854.
— — *Cotteau*. Moll. foss. de l'Yonne, p. 76, 1854.
— — *Pictet* et *Renevier*. Pal. Suisse, p. 97, pl. xiii, figs. 1, 2, 1857.
— — *Raulin* et *Leymerie*. Statist. l'Yonne, p. 424, 1858.
— — *Desor* et *Gressly*. Étud. géol. sur le Haut Jura, p. 37, 1859.
— — *De Loriol*. Descr. des Anim. invert. du Haut Salins, p. 73, 1861.
— — *Coquand*. Monogr. Étage Aptien d'Espagne, p. 133, 1866.

Shell subcrescentic, much inflated anteally, compressed, attenuated and rostrated posteally; umbones large, elevated, sub-involute, and recurved, their apices are attenuated and contiguous when the valves are closed; the anterior side is short, forming a wide and somewhat depressed surface, arcuately curved with the lower border, which is irregularly dentated by the extremities of the costæ; it is somewhat excavated or sinuate posteally. The ligamental space is narrow, lengthened, and inter-umbonal, extending both anteally and posteally to the umbones. The escutcheon is large even when compared with other lengthened examples of the *Scabræ*, forming a deep concavity occupying almost the whole of the upper surface of the shell; its upper border is raised and dentated by the extremities of a series of costellæ, elevated, narrow, and wrinkled or scabrous, passing obliquely across its surface; immediately between the umbones the transverse costellæ pass across a groove, which forms the commencement of the area, and are united to the costæ on the other portion of the valve. The area commences as a furrow, which in its course downwards becomes bounded by gradually widening rounded elevations, traversed transversely by numerous lines or plications, which upon approaching the widening posteal extremity become large, irregular, and rugose. The

rows of costæ upon the sides of the valves are numerous (24 to 27), narrow, and much elevated, passing from the area obliquely downwards and forwards, large in their middle portions and attenuated at their two extremities; nearly straight upon the anterior face, they disappear at the border, their other extremities form a slight undulation as they approach the area. The few last-formed or posteal costæ are small, narrow, nearly perpendicular, or slightly waved; their lower extremities project, forming an irregular dentated lower border; their upper extremities are united to the transverse costellæ on the area. All the costæ have narrow, fringing, obtuse, nodose elevations, more or less irregular in their size and prominence, minute and evanescent near to the extremities of the rows. The lines of growth are conspicuous on the anteal face of the shell, and in well-preserved specimens each of the intercostal spaces has a small median elevated line; frequently, however, this feature is only obscurely indicated. The typical form occurs in the Neocomian formation; delicately preserved examples are obtained in the Isle of Wight at Atherfield in the beds called "Crackers," and also in other beds and localities in a less favorable condition of preservation. Few of the specimens exceed two inches in length, measured upon the area. Internal moulds, which probably belong to *T. caudata*, are smooth, and their borders are without indentations; their apices are more erect than in specimens with the tests preserved.

British specimens differ materially from the figures of this species given in the 'Paléontologie Française' by D'Orbigny, where a specimen about two inches in length with eighteen costæ upon the sides of the valves is represented with an area which retains bounding narrow ridges and regular transverse costellæ throughout its entire length, or, in other words, the peculiarities of the immature state are continued in the more advanced stage of growth, an abnormal condition to which we find no approximation.

The specimens figured by Agassiz are all apparently immature, and are only moulds upon which some portions of the surface characters are visible. His description is limited in accordance with such unsatisfactory materials.

Stratigraphical position and Localities.—The Cracker beds of the Neocomian formation at Atherfield have yielded it rather abundantly.

Foreign Localities.—France: Bettancourt, Auxerre, Saint Saveur, Comble, Morteau. Switzerland: Neuchatel.

Trigonia scabricola, *Lyc.* Plate XXVII, figs. 4, 5, 5 *a*, 5 *b*.

Trigonia scabra, *Morris.* Catal., p. 229, 1854. (Non *T. scabra*, Lam.)

This large and abundant *Trigonia* of the Blackdown and Haldon Greensand has usually been referred to either *T. scabra* or *T. caudata;* to the latter species it is

undoubtedly nearly allied; more especially small and immature examples of each are often difficult to distinguish. Adult forms present some differences of figure; *T. scabricola* is more inflated anteally, and its anterior face is more flattened; the umbones are larger, more produced and recurved, so that the caudal or posteal portion of the shell forms a smaller relative proportion of the whole; the costæ have their upper or posteal portions less attenuated, they are also distinctly crenulated, and the crenulations upon the costæ generally are more unequal, larger, and more irregular, thus forming a peculiarly roughenened surface. The posteal portion of the narrow area in *T. caudata* forms a series of large, transverse, very irregular and prominent costellæ; in *T. scabricola* the area has the rugæ regular and inconspicuous; the wide interstitial spaces in *T. caudata* have each a plain median small costa, a feature which is altogether absent in *T. scabricola*. There is required, therefore, only a fairly represented series of each form to demonstrate their distinctness as species. The escutcheon is peculiarly large and deeply excavated, exceeding those features in *T. caudata;* its transverse costellæ are similar in character, but are more rugose, their upper extremities forming a peculiarly jagged irregular outline upon the upper border. Measurements of a specimen not of the largest dimensions:—Length upon the angle of the valve 31 lines; across the area and escutcheon 6 lines; across the pallial surface 18 lines; thickness anteally through a single valve $11\frac{1}{2}$ lines.

Two foreign allied forms of the genus require comparison and separation. The large species figured for *T. aliformis* by Goldfuss ('Petref.,' tab. 137, figs. 6, 6 *a*) has the posteal portion of the shell wider and less attenuated; the upper or attenuated portions of the costæ are without the flexure seen in *T. caudata* and *T. scrabricola;* the anteal portion of the shell is more produced and its costæ are concentric; they are, therefore, without the abrupt obliquity of *T. scabricola.*

T. plicato-costata, Nyst and Galeotti ('Bull. de l'Académie Roy. Bruxelles,' tome vii, 2 partie, p. 221, fig. 1, 1840), from limestone at Tehuacan, in Mexico, was referred by them to Jurassic strata, an error which was corrected by D'Orbigny ('Prodrome de Paléont.,' vol. ii, p. 240, No. 605), who placed the species in his Étage 22 Sénonien, or highest stage characterised by Cretaceous *Trigoniæ*. The figure, which appears to be very well drawn, has the anterior side much more produced and the posteal portion less attenuated than in *T. scabricola;* the costæ, which are similarly crenulated, are nearly concentric anteally, are slightly curved in the same direction as the smaller or posteal rows; their direction, therefore, differs materially from the corresponding parts in the British species. The escutcheon and area, on the other hand, appear to correspond very nearly with *T. scabricola.*

Stratigraphical position and Localities.—*T. scabricola* accompanies *T. aliformis* in the beds of the Blackdown and Haldon Greensand. Certain internal moulds brought to my notice by Mr. Cunnington from the Upper Greensands of Wiltshire probably belong

to the same species; they are without the crenulations upon the pallial border which characterise both *T. aliformis* and *T. Vectiana.*

TRIGONIA FITTONI, *Desh.* Plate XXIII, figs. 4, 4 *a*, 4 *b*, 5.

TRIGONIA FITTONI, *Deshayes.* Leymerie, Mém. de la Soc. géol. Fr., tom. v, pl. ix, fig. 6, 1842.
— — *D'Orbigny.* Paléont. Fran., Terr. Crét., vol. iii, p. 140, pl. 290, figs. 1—5, 1843.
— — *Ib.* Prodrome de Paléont., vol. ii, p. 137, No. 243, 1850.
— — *Cotteau.* Moll. foss. de l'Yonne, p. 77, 1854.
— — *Raulin* et *Leymerie.* Statistique de l'Yonne, p. 473, 1858.

Shell ovately oblong, very convex anteally, depressed and somewhat attenuated posteally; umbones large, much elevated, slightly recurved, much incurved, their apices are in contact when the valves are closed, antero-mesial; anterior side short, its border curved elliptically with the lower border; superior border concave; siphonal border short, nearly perpendicular, rounded at its extremities. Escutcheon small and lengthened, moderately wide and concave anteally, narrow and pointed posteally; its superior border is much raised upon the anteal half of its length bounding the ligamental fissure, which is lengthened, extending both anteally and posteally to the umbonal apices. Area moderately wide, destitute of bounding carinæ, traversed by a deeply indented longitudinal mesial furrow; its surface, in common with the escutcheon, has a numerous (about 20) series of delicate, narrow, regularly papillated costellæ, which descend almost perpendicularly from the superior border; they enlarge slightly as they cross the area, and again curving upwards outwardly meet the extremities of the pallial costæ at the divisional line of the valve, forming with them acute angles; about three fifths of the length of the divisional line is occupied by the extremities of these costellæ, which extend upon the superior half of the area even to its posteal extremity; the posteal portion of the lower moiety of the area, therefore, is traversed only by delicate lines of growth. The other portion of the surface is occupied by about twenty rows of elevated, rounded, concentric, regularly papillated costæ, attenuated at both of their extremities; the last-formed seven rows curve upwards almost perpendicularly to the angle of the valve, their lower extremities forming a jagged outline at the lower border, alternating with the projecting extremities of the costæ upon the other valve. The anterior face of the shell has the wide intercostal spaces occupied by numerous small, short, horizontal, rather obscure, supplementary costellæ, two or three of which occur in each space, a feature also seen in *T. aliformis ;* each of the papillæ or little nodes fringing the costæ has a little pillar or plication passing downwards, a feature which is distinct only

upon the first-formed ten or twelve rows of costæ. The lines of growth are delicate, they are conspicuous upon the anterior face of the shell, and also upon the area and escutcheon. The test is thin and fragile. The internal mould has its general figure and outline so nearly resembling specimens with the test preserved that it is recognised without difficulty; its lower border has indentations produced by the extremities of the costæ; the surface is usually plain, but sometimes it has faint impressions of the costæ; the mesial furrow of the area is well defined.

The specimen figured by D'Orbigny (pl. 290, figs. 1, 2) is of larger dimensions than occurs in Britain; the drawing is not altogether free from objection; fig. 2 has the escutcheon too wide posteally; it appears to form a deep concavity and gives no sufficient indication of the considerable elevation of the superior border at the junction of the valves; the curved costellæ upon the escutcheon and area are only about half as numerous as in British specimens; these features indicate a distinct variety if they are faithfully depicted; the small supplementary costellæ upon the anterior face of the shell are not noticed either in the figures or the description.

Of the highly ornamented section of the *Scabræ* few forms can surpass in beauty and delicacy the surface of the present species; the area and escutcheon more especially present, under a magnifier, the semblance of a series of symmetrical, closely arranged bead-like rows of necklaces, curving upwards at both of their attenuated extremities. It will not readily be mistaken for any other *Trigonia.*

Proportions.—The height is equal to four fifths of the length; the diameter, through the united valves, is equal to half the length.

Stratigraphical position and Localities.—*T. Fittoni* is limited to the lower portion of the Gault, which at Folkestone has produced a considerable number of the internal moulds, to some of which the test is attached, but for the most part in portions only. Well-preserved examples, therefore, rank as the most rare fossils of the Gault.

France: in the sandy beds of Géraudet, Evry, Apothement, Macheroménil, Seignélay.

Trigonia pennata, *Sow.* Plate XXIV, figs. 4, 5.

Trigonia pennata, *Sowerby.* Min. Conch., vol. iii, p. 63, tab. 237, fig. 6, 1819.
— — *Pusch.* Polens Palæont., p. 60, 1837.
— — *Agassiz.* Trigonies, pp. 9 and 52, 1840.
— — *Morris.* Catalogue, p. 229, 1854.

Trigonia pennata and *Trigonia sulcataria* are the only known British examples of a small group of the *Scabræ*, which is represented in France by other species and by individuals the dimensions of which far surpass their British analogues; the British Museum possesses a fine series of French specimens pertaining to this group. Like

certain of the Upper-Jurassic *Glabræ* they have a space, anterior to the divisional angle of the valve, devoid of the costæ, which occupy the anteal portion of the shell, but possessing a feature peculiar to this group, inasmuch as the space is occupied by a series of faintly defined perpendicular costellæ which are directed upwards, some from the pallial border, others from the posteal extremities of the costæ, to the angle of the valve; the area and escutcheon have also their transverse costellæ; the whole of this ornamentation is slightly crenulated; it may be designated the *pennata* group.

Trigonia pennata, Sow., shell ovately trigonal, convex; umbones antero-mesial; only slightly recurved, not prominent; anterior border rounded, produced; lower border lengthened, curved, its posteal extremity pointed; siphonal border sloping obliquely; escutcheon rather wide, depressed, its border nearly straight. Area wide, flattened, its surface forming a considerable angle with the other portion of the valve; its surface is traversed transversely by small rows of scabrous costellæ, which curve obliquely from the angle of the valve, pass uninterruptedly across a slight elevation which forms the upper boundary of the area and are continued across the escutcheon. The other portion of the valve has the costæ (about thirty in fully developed forms) prominent, regular, nearly horizontal, and closely arranged; posteally their extremities form nearly right angles with the lower extremities of a much smaller, more faintly defined, perpendicular series of costellæ, which terminate upwards at the divisional angle of the valve throughout its entire length; both costæ and costellæ are minutely crenulated. The posteal costellæ and those of the area diverge from the angle of the valve, as stated by Mr. Sowerby, like the rays of a feather.

D'Orbigny ('Pal. Fran., Terr. Crét.,' vol. iii, p. 150) made *T. pennata* a synonym of *T. sulcataria*, Lam., an error which probably originated in the very incorrect drawing of Sowerby's species in the 'Mineral Conchology,' where the apex of the valve is represented as considerably produced and recurved; there is also apparently a divisional line or ridge crossing the valve obliquely and intersecting the rows of costæ at the point where they are united to the extremities of the smaller or perpendicular costellæ. Neither of these characters exist; in fact, the artist appears in some measure to have made up the great imperfections of the type-specimen with an ideal representation. The type-specimen now in the British Museum is very defective, and contrasts strongly with the original drawing; its size agrees nearly with the smaller of our figures. Compared with *T. sulcataria*, *T. pennata* is a much smaller species, differing from the former both in the figure and ornamentation; both have the series of scabrous costæ anteally, but *T. pennata* has the general figure less inflated and more lengthened; the umbones are less elevated and less recurved, the area supplies the most striking distinctive feature; it is regularly transversely costellated almost its entire length. In Lamarck's species it is smooth, excepting near to the umbones. The latter species has the costæ shorter, more oblique, and more distantly arranged; the series of small perpendicular or

posteal costæ are smaller; they occupy a larger ante-carinal space and are more faintly defined.

Dimensions. A specimen of the largest size has the length $10\frac{1}{2}$ lines; height 9 lines; usually the dimensions are much less, or nearly coincide with the type-specimen of Sowerby.

Stratigraphical positions and Localities. This small and well-characterised species appears to be rare. Mr. C. J. A. Meyer has obtained it at Dunscomb Cliffs, to the eastward of Sidmouth, in Sandy Chloritic Marl; Mr. Cunnington has a fine specimen reputed to have been obtained in the vicinity of Folkestone; Mr. Vicary has collected several specimens in the pebbly bed (Upper Greensand) which overlies the Greensand at Great Haldon. The type-specimen of Mr. Sowerby, now in the British Museum, is from Teignmouth. *T. pennata* is usually accompanied by the following congeneric forms—*T. sulcataria, T. Vicaryana,* and *T. Meyeri.* It therefore pertains to a higher position than the Greensand at Blackdown and Haldon, or to the Upper Greensand and Chloritic Marls of South Devon.

TRIGONIA SULCATARIA, *Lam.* Plate XXVI, fig. 8.

TRIGONIA SULCATARIA, *Lamarck.* Anim. sans Vert., tom. vi, p. 92, No. 9, 1819.
— — *Defrance.* Dict. des Sc. Nat., tom. lv, p. 295, 1828.
— — *Deshayes.* Edit. *Lamarck,* tom. vi, p. 517, No. 9, 1835.
LYRODON SULCATUM, *Goldf.* Petref. Germ., vol. ii, tab. 117, fig. 7, 1836.
TRIGONIA SULCATARIA, *Agassiz.* Trigonies, p. 33, pl. xi, fig. 17, 1840.
— — *D'Orbigny.* Paléont. Fran., Terr. Crét., vol. iii, p. 150, pl. 294, figs. 5–9, 1843.
— — *D'Orbigny.* Prodrome de Paléont., vol. ii, p. 161, No. 325, 1850.

This, our second and larger species of the *pennata group,* differs from *T. pennata* in the general figure, which is much shorter posteally, larger and more inflated anteally; the umbones are more nearly mesial, more elevated, and more recurved; the costæ are somewhat fewer (about 24), larger, more distantly arranged, shorter, and directed somewhat obliquely downwards posteally; the ante-carinal space, which is occupied by the posteal perpendicular costellæ, is more depressed; it extends upwards even to the apex of the valve. The area is shorter, so that the angle of the valve has a greater curvature; its costellæ are very delicate and closely arranged; they are limited to the upper half of the area, the lower portion of which is plain; it is traversed by a distinct mesial furrow. The escutcheon is large, slightly concave, and only indistinctly separated from the area, the delicate costellæ of which traverse the escutcheon also, transversely and with increased prominence.

Agassiz placed *T. sulcataria* in the section of the *Undulatæ* probably from the angles formed by the two series of costæ; but on the other hand he placed *T. pennata* with the *Costatæ.* The present arrangement of the group with the *Scabræ* is founded upon the crenulations of the costæ and the presence of crenulated transverse costellæ, which cross both the escutcheon and area, together with the absence of bounding carinæ to the area; whereas in the *Undulatæ* the escutcheon is invariably plain. Agassiz has also made *T. sinuata*, Park., a synonym of *T. sulcataria,* 'Trigonies,' pp. 33, 34. I do not perceive even a remote resemblance in Parkinson's shell, which is well figured in his 'Organic Remains,' to the *T. sulcataria* of Lamark.

Stratigraphical position and Localities. In Britain *T. sulcataria* is rare and usually badly preserved. Mr. Meyer has procured specimens in Chloritic Marls at Dunscomb Cliffs associated with *T. pennata* and *T. Meyeri;* Mr. Vicary has also obtained it associated with *T. pennata* in a pebbly bed with Greensand fossils overlying the Greensand at Great Haldon. Hitherto no British specimen having the test preserved and its outlines perfect has come under my observation; their condition is that of well-preserved moulds of external casts which have no traces of the perpendicular plications upon the costæ nor of the lines of growth upon the ante-carinal space; the costellæ upon the area cover a larger portion of its surface than is shown in the figures of Goldfuss, of D'Orbigny, and of Agassiz; the figure given by the latter author presents differences both in the posteal or perpendicular costæ and in the area, which indicate a distinct species. It is intended to figure a second specimen of *T. sulcataria* from Great Haldon upon a future plate.

French specimens of much larger dimensions and in a fine state of preservation occur in the Greensand of Le Mans. The British Museum has a good series of examples from that locality, numbered "34,888." There are also two fine examples of an allied species named *T. Nereis,* D'Orb., 'Prodr. de Paléont.,' vol. ii, p. 162, No. 322. Of equal size to *T. sulcataria,* it differs in having the surface ornaments far more minute and delicate; it differs also from the brief description given by D'Orbigny in having the ante-carinal space similar in character to that in *T. sulcataria;* in *T. Nereis* the space is stated to be plain.

TRIGONIA SPINOSA, *Park.* Plate XXIII, fig. 10; Plate XXIV, figs. 8, 9; moulds of external casts, Plate XXVIII, figs. 1, 2.

TRIGONIA SPINOSA, *Parkinson.* Org. Rem., vol. iii, pl. xii, fig. 7, 1811.
— — *Sowerby.* Min. Conch., vol. i, tab. lxxxvi, p. 196, 1815.
— — *Pusch.* Polens Palæont., p. 60, 1837.
— PYRRHA, *D'Orbigny.* Prodrome de Paléont., vol. ii, p. 161, No. 326, 1850.
— SPINOSA, *Morris.* Catalogue, p. 229, 1854.
— — *Phillips.* Geology of Oxford, p. 439, 1871.

Shell subovate; moderately convex mesially; rather depressed near the circumference at the borders of the valves; umbones small, obtuse, little produced, and slightly recurved; anterior border produced, curved elliptically with the lower border; hinge-border slightly convex, moderately lengthened, its extremity forming an obtuse angle with the siphonal border, which is somewhat curved, its length being equal to two thirds of the hinge-border; its lower extremity is curved with the pallial border. The oblique divisional angle of the valve is well defined; from it diverge on each side a series of narrow, elevated, closely arranged, spinose costæ, which pass each other with a slightly oblique curvature across the opposite portions of the valve; those which cross the area and escutcheon are the smaller; and, in conformity with the general figure of the valve, are also the more closely arranged; the pallial costæ increase in size downwards towards the lower border, the more anteal ones curving moderately forwards; the spines upon the high-ridged pallial costæ are obtuse and erect; each has its perpendicular plication upon the sides of the narrow ridge; the spines upon the area and escutcheon are much smaller and have little prominence. The surface of the escutcheon is narrow and slightly depressed; a small elevation separates it from the surface of the area, which is somewhat concave, and destitute of any mesial furrow.

Dimensions of a large specimen. Length, measured upon the divisional angle of the valve, 25 lines; across the valve at right angles to the divisional angle, 21 lines; convexity of a single valve 5 lines.

Affinities and differences. I am unable to identify with Parkinson's species the *T. spinosa* of D'Orbigny ('Pal. Fran., Terr. Crét.,' vol. iii, p. 154, pl. 297). The latter has the general convexity much greater; the umbones are more produced, the area is more concave, and is pointed at its lower extremity; it has also a mesial furrow; the escutcheon is wider, shorter, and more concave, so that, when the valve is placed upon its side and viewed from above, the escutcheon is but partially seen. The pallial costæ have much greater curvature; they have delicate crenulations, but are without prominent obtuse spines; it does not appear to agree strictly with any British species.

The same author in his 'Prodrome de Paléontologie,' vol. ii, p. 161, separated from *T. spinosa* a supposed allied form under the name of *T. Pyrrha*, characterised by the few following words: "espèce voisine du *T. spinosa*, mais avec des côtes et des tubercles bien plus gros."

Having due regard to the erroneous figure and description of *T. spinosa* above mentioned, taken in connexion with the few words assigned to *T. Pyrrha*, an impression is conveyed that the latter form is the real representative of the species indicated by Parkinson and Sowerby.

Agassiz figured for *T. spinosa* ('Trigonies,' pl. 7, figs. 4—6) a little mould of an external cast from Upper Greensand of the Undercliff, Isle of Wight; the reader will find it figured and described in the present Monograph under the name of *Trigonia Archiaciana*, p. 140, Plate XXV, fig. 10 (mould).

Another allied form which has sometimes been mistaken for *T. spinosa* is *T. ornata*, D'Orb.; the latter species, which is limited to the Neocomian formation, will also be found figured and described in the present Monograph. Compared with *T. spinosa,* and represented by an uncompressed specimen, it will be seen to have much greater convexity; the umbones are larger and much more recurved; the divisional angle of the valve has greater prominence; the surface of the area is steeper and narrower; the escutcheon is wider and more excavated; the pallial costæ have much greater curvature; they are without obtuse spines, having their rounded surfaces only crenulated; their attenuated extremities also form a sinuation as they pass upwards to the angle of the valve; the perpendicular plications occupying the intercostal spaces are also unusually prominent.

A little *Trigonia* figured by Nilsson under the name of *T. pumila* ('Petref. Sulc.,' tab. 5, fig. 7) has been referred to by Pusch as probably representing a young specimen of *T. spinosa;* the figure does not appear to be a satisfactory representation of Parkinson's species; the small portion of the area visible indicates that its surface forms a considerable angle with the other portion of the valve; the costæ differ in being without distinct spines, and in having a considerable curvature. The general aspect agrees better with a small example of *T. Archiaciana.*

T. Lamarckii, Matheron ('Catal. des Corps org. foss. du Départ. des Bouches du Rhône,' pl. 22, figs. 5—7), possesses some general resemblance to *T. spinosa* in the outline and in the arrangement of the spinose costæ; but the convexity is more considerable; the area is more excavated; the escutcheon has greater breadth; the costæ have greater curvature and much less prominence, their spines are much smaller, more numerous, and more pointed.

The British Museum possesses the unusually fine specimen of *T. spinosa* figured in the 'Mineral Conchology,' numbered "50,003;" but it is equalled in size by other examples in the same collection. Our figures represent much smaller but equally characteristic shells; the two specimens on Plate XXIV are from the Greensand of the Blackdown region; apparently it is absent in the more western outliers of the same formation at Great and Little Haldon.

The specimen figured (Plate XXIII, fig. 10) is from the Upper Greensand of the Isle of Wight; it is somewhat more lengthened and has greater convexity, but differs in no other feature; it is the sole example having the test preserved and obtained in the Upper Greensand which has come under my notice; specimens from that formation without the test, of various dimensions, are not uncommon, both in the Isle of Wight and near to Devizes; from the latter place Mr. Cunnington kindly forwarded numerous specimens. The usual condition of these external moulds is very defective. For the most part they are flattened from vertical pressure; their costæ have little prominence, and their spines are indicated only by slight irregularities upon their upper borders. It is intended to figure two of the larger of the moulds on Plate XXVIII.

Upon the whole, well-preserved specimens of *T. spinosa* rank with the rarer Testacea of the Greensand. No specimen obtained at any foreign locality has come under my observation.

TRIGONIA ORNATA, *D'Orb.* Plate XXIV, figs. 6, 7.

TRIGONIA SPINOSA, *De la Beche.* Geol. Manual, p. 287, 1832.
— — *Mantell.* Geol. South-east of England, p. 179, 1833.
— ORNATA (*spinosa*, var.), *Fitton.* Stratigraphical Section in the Isle of Wight, Quart. Jour. Geol. Soc., vol. iii, No. 11, p. 289, fossil No. 65, 1847.
— — *D'Orbigny.* Prodr. de Paléont., vol. ii, xvii, Étage, p. 106, No. 709, 1850.
— — — Pal. Fran., Terr. Crét., 3, p. 136, pl. 288, figs. 5–9, 1843.
— — *Morris.* Catalogue, p. 229, 1854.
— — *Pictet.* Paléont. Suisse, vol. i, pl. xii, fig. 4, 1857.

Shell sublunate or crescentric, convex; umbones antero-mesial, prominent, obtuse, and recurved; anterior and lower borders rounded elliptically; hinge-border short, somewhat concave, sloping downwards, and forming a distinct, obtuse angle with the posteal border of the area, which is of moderate breadth and terminates downwards, forming a right angle with the lower border of the valve. In conformity with the considerable convexity of the shell the area is much curved; it is of moderate breadth; it has a slight median furrow; its inner and outer border are rendered conspicuous by the terminations of its transverse costellæ, which are large, slightly waved, and striated. The escutcheon is of moderate breadth, much excavated outwardly; its superior border is raised; it is traversed by transverse costellæ similar to those of the area; together with the area the posteal or superior surface forms a considerable angle with the other portion of the valve. The costæ are numerous (about twenty-one), large, rounded, and closely arranged; they are somewhat less numerous than the costellæ upon the area, the extremities of which they meet at the prominent dividing ridge or angle of the valve, with which they form an angle greater than a right angle; they pass downwards, nearly in a straight direction, enlarging rapidly about the middle of the valve, and then curving forwards gracefully; they curve somewhat upwards as they meet the anterior border; the last-formed seven costæ diminish in size symmetrically, and pass almost perpendicularly downwards to the lower border; the costæ have their sides regularly plicated, forming rounded elevations upon the summits of the costæ. Its nearest ally is *T. Archiaciana*, compared with which it has greater convexity; the umbones are much more prominent and are more recurved; the area has less breadth and forms a greater angle with the other portion of the valve; the costæ are different in figure; their anteal enlargement

and posteal attenuation and slight sinuation upwards towards the angle of the valve are also distinctive features. The costellated, wider, and flattened area serves to separate it from *T. crenulata* and also from the little *T. Vectiana,* which is much more produced and attenuated posteally; the apices are also far more recurved.

Stratigraphical position and Localities. *T. ornata* occurs somewhat rarely in the Perna bed of the Neocomian formation at Atherfield; the valves are disunited; the test is preserved. At Hythe the Neocomian Sandstone has produced it in great profusion, for the most part indifferently preserved and flattened from pressure.

France: St. Dizier, Vassy, Aucerville, Auxerre, Perte-du-Rhône (Ain).

Note.—In the introductory portion of the present Monograph, p. 8, *T. Picteti,* Coq., is mentioned as one of the British species; the subsequent acquisition of uncompressed examples of *T. ornata,* with the test preserved, has convinced me that our specimens should be referred to the latter species. It may also be remarked that the figures of *T. ornata* given in the 'Paléontologie Française' are not good representations of British specimens, and that the figure in Pictet's work is a much nearer approximation to them.

TRIGONIA ARCHIACIANA, *D'Orb.* Plate XXIII, fig. 7; Plate XXV, fig. 10 (mould).

? TRIGONIA PUMILA, *Nilsson.* Petref. Suec., tab. v, fig. 7, 1827. (Young example.)
— SPINOSA, *Sowerby.* Geol. Trans., 2nd ser., vol. iv, pl. xiii, fig. 3, p. 338, 1836.
— — *Agassiz.* Trigonies, p. 30, tab. vii, figs. 4–6, 1840. (Mould.)
— ARCHIACIANA, *D'Orbigny.* Paléont. Fran., Terr. Crét., vol. ii, pl. 290, figs. 6, 8, 10, 1843.
— — *Pictet* et *Roux.* Descr. Moll. foss. Grès vert, pl. xxxv, fig. 4, 1847.
— — *D'Orbigny.* Prodrome de Paléont., vol. ii, p. 137, No. 241, 1850.
— — *Morris.* Catalogue, p. 228, 1854.
— — *Pictet* et *Renevier.* Paléont. Suisse, Terr. aptien de la Perte-du-Rhône et des Env. de St. Croix, p. 95, pl. xli, fig. 3, 1857.

Shell with nearly the general outline and figure of *T. ornata,* but smaller, with the umbones more pointed and less recurved; the general convexity is also less; the area is more expanded, its surface forming a smaller angle with the surface of the other portion of the valve; the costæ are elevated, but narrower and more closely arranged than in *T. ornata;* they curve with great regularity obliquely downwards and forwards, but are without the sinuation which their attenuated carinal portions form in *T. ornata*—a feature which characterises that species. The divisional line of the valve forms a distinctly

elevated narrow ridge, from the sides of which the costæ and costellæ diverge, each one forming a considerable angle with its corresponding ridge; the costellæ are therefore large, but more closely arranged than in *T. ornata;* the escutcheon is smaller or narrower, the costellæ of the area pass across it in a similar manner. The intercostal perpendicular plications are small and densely arranged; they render the upper borders of the costæ prominent and obtuse; they constitute a much less prominent feature than in the allied species *T. ornata* and *T. Vicaryana.* For comparison with *T. Upwarensis* see that species.

The foregoing description is founded upon specimens from the Greensand of Great Haldon, in which rock the test is so fragile that an entire shell is rarely obtained. Our figured example is of the largest dimensions.

The Upper Greensand of Sidmouth is also a locality for *T. Archiaciana*, where the specimens are usually ill-preserved.

A little mould figured by Agassiz ('Trigonies,' tab. 7, figs. 4—6) for *T. spinosa* is probably a small specimen of *T. Archiaciana;* it has impressions of the costæ, but the area and escutcheon are represented only by the scar of the posterior adductor muscle. The deficiencies of the specimen rendered Agassiz' description meagre and insufficient; it was obtained in the Upper Greensand of the Undercliff, Isle of Wight. Our little example (Plate XXV, fig. 10) represents a specimen obtained at the same locality and in a condition precisely similar. Specimens in a like state of preservation also occur in the Upper Greensand of Warminster. The general figure and characters of the costæ resemble *T. Archiaciana*, but a rigid scrutiny is impracticable; there can be no doubt that it is altogether distinct from *T. spinosa.* Of this latter species additional specimens from the Upper Greensand, and deprived of the test, will be given on Plate XXVIII.

The small and insufficient figure of *T. pumila*, Nilsson, above referred to, only enables me to quote it doubtfully as probably representing a small specimen of *T. Archiaciana.* It was regarded by Pusch ('Pol. Palæont.,' p. 60) as a young example of *T. spinosa;* the costæ have their features very imperfectly represented.

French localities given by D'Orbigny are Varennes, Saulce-au-Bois, Mont Blainville Seignelay.

Trigonia Vicaryana, *Lyc.*, sp. nov. Plate XXV, figs. 8, 9.

Shell ovately elongated, convex, produced and pointed at the umbones, depressed posteally; umbones subanterior, elevated, pointed, recurved; anterior side short, its border curved elliptically with the lower border; superior border nearly straight, rounded posteally with the wide siphonal border. Area wide, flattened, its surface together with

the escutcheon equal to about two fifths of the entire valve; it has a faintly defined, mesial, oblique depression, and is covered by a very numerous and delicate series of obliquely curved scabrous costellæ which nearly disappear upon its posteal portion; the escutcheon is of moderate breadth, separated from the area only by the border of its concave surface, and by the greater prominence of its costellæ, which are continuations of those upon the area; these form a slight angle at the border of the escutcheon and traverse it in a direction directly transverse to its superior border, which is somewhat raised. Upon the divisional line of the valve the extremities of the costellæ are united to the superior or attenuated extremities of the pallial costæ, forming with them acute angles. The rows of costæ, which are very numerous and small, are curved obliquely downwards; their upper borders form projecting obtuse nodosities, the extremities of a multitude of perpendicular regular plications or little pillars which cross the costæ. Fully developed specimens have the plications slightly waved and somewhat irregular near to the pallial border, where the extremities of the costæ become more distant. No specimen altogether entire has come to my notice.

It will be observed that the specimens figured on Plate XXV constitute two varieties, which pertain to different localities and beds of the Upper Greensand. The left-hand figure (8) is from the Chloritic Sand at Chardstock; it also occurs at Dunscomb cliffs eastward of Sidmouth, and near to Axmouth in the Chloritic marly beds; the costæ are smaller than in the other variety, and more closely arranged; they also form a much smaller angle with the costellæ upon the area; their upper borders have also less prominence. Specimens are in the collection of the Royal School of Mines, in Mr. C. J. A. Meÿer's collection, and in my own cabinet. The right-hand figure (9) is apparently less rare, and has been obtained by Mr. Vicary in a pebbly bed overlying the Greensand at Great Haldon. No specimen altogether perfect has been obtained.

This, which I arrange as the typical form, has the costæ somewhat larger anteally and more widely separated; they become much attenuated at the divisional angle of the valve, and form considerable angles with the costellæ upon the area; the intercostal perpendicular plications are also larger and more conspicuous. Some specimens are delicately silicified, and exhibit the most minute surface ornaments with great clearness. It is intended to give additional figures of the typical form in a future plate.

Affinities and Differences. Defective specimens of the variety with the smaller costæ were at first mistaken for *T. tenuisulcata*, Dujardin ('Mém. Soc. Géol. de France,' vol. ii, pl. 15, fig. 11); the examination of more satisfactory examples has led to their separation from Dujardin's species, which has the costæ more minute, more closely arranged, and peculiarly straight near to the pallial border; the area and escutcheon are also smaller and less expanded than in the British species.

T. Lamarckii, Matheron ('Catal. des Corps org. foss. du Départ. des Bouches du Rhône,' pl. 22, figs. 5—7) has affinities with our species in the general figure and the

surface ornaments, excepting that the pallial costæ are much more widely separated and have greater curvature, forming much smaller angles with the costellæ upon the area; their upper borders are also sharply spined; the escutcheon is not seen upon the same figure, which proves that its surface is much depressed; the umbones are less produced and pointed than in our species.

T. crenifera, Stoliczka ('Mem. Geol. Survey of India,' vol. iii, p. 318, pl. 15, figs. 13, 13 *a*), from Cretaceous Rocks of Southern India, is nearly allied to our species in its surface ornaments, but differs considerably in the general figure, which is much shorter, or subquadrate; the dimensions are also much smaller.

The name is intended as an acknowledgment of important assistance afforded me by Wm. Vicary, Esq., F.G.S., in the loan of *Trigoniæ* from the Greensands of the Blackdown and Haldon districts, of which his extensive and valuable collections of Devonshire fossils have supplied ample and instructive materials.

TRIGONIA UPWARENSIS, *Lyc.*, sp. nov. Plate XXIII, figs. 8, 9.

TRIGONIA SPINOSA, *J. F. Walker*. On some Coprolite Workings in the Fens; Geological Magazine, vol. iv, p. 310, 1867.

Shell suborbicular or subovate, convex; umbones large, obtuse, little elevated, and slightly recurved; angle of the valve well defined, not prominent, much curved; hinge-border somewhat concave, sloping obliquely, its extremity forming an obtuse angle with the siphonal border, the length of which is about equal to the hinge-border; the anterior and lower borders are curved elliptically, forming an extremity somewhat pointed posteally at the junction with the siphonal border. The escutcheon is short and concave, of less breadth than the area; its surface and also that of the area is traversed by numerous, closely arranged, transverse, depressed, but rounded, scabrous costellæ; their outer extremities are in contact at the angle of the valve with the posteal attenuated extremities of the costæ; the latter are somewhat less numerous and larger than the costellæ, with which they form considerable angles. The sides of the valves have the rows of costæ (twenty-four in full-sized forms) narrow, little elevated, their summits rounded, their sides with closely placed perpendicular plications; the extremities of the rows are attenuated and curve upwards; the posteal extremities more especially curve upwards perpendicularly to the angle of the valve. Occasionally the lines of growth are strongly defined near the pallial border; they impress the costæ and obliterate the perpendicular plications; they also become conspicuous on the area.

Young specimens have less convexity and are more pointed at both of their

extremities; the concentric curvature of the costæ is less considerable than in adult forms.

The specimens examined are moderately numerous, consisting of valves either united or separated; their tests are converted into carbonate of calcium, and measure from six to twelve lines across; they vary somewhat in the closeness with which the costæ are arranged and in the size of the costellæ upon the area and escutcheon; the costellæ also vary in their number; thus, some examples have the extremities of the costæ and costellæ meeting at the angle of the valve with corresponding regularity over nearly the entire length of the area; in other specimens there is no near corresponding order, the costellæ are then more numerous and smaller.

Affinities and Differences. In general aspect this small species has a considerable resemblance to *T. Archiaciana*; but the outline is more nearly circular; the umbones are less produced or more obtuse; the general convexity is greater; the costæ are more numerous and more closely arranged; they have less prominence and greater curvature anteally; their intercostal spaces are therefore narrower, and their plications have much less prominence near the pallial border. The costellæ on the area and escutcheon are also smaller and more numerous; for the most part they touch the extremities of the costæ at the angle of the valve, which does not form a distinct narrow dividing ridge as in *T. Archiaciana;* the escutcheon is shorter, wider, or more horizontal; the siphonal border is more lengthened.

Compared with *T. spinosa,* the valves are of smaller size and have greater convexity; the umbones are larger and more prominent; the area is smaller, its slope is comparatively steep, its surface forming a more considerable angle with the other portion of the valve; the differing features presented by the costæ are also very conspicuous; the smallness and close arrangement of the rows, their little prominence, their rounded upper borders, and their considerable or concentric curvature, so distinct from the high-ridged nearly straight costæ and obtuse spines of *T. spinosa.*

Dimensions. A large specimen has the length, measured upon the carina, of 12 lines; across the valve at right angles to the carina, 10 lines, of which the area occupies $3\frac{1}{2}$ lines; length of the escutcheon 7 lines; length of the siphonal border $5\frac{1}{2}$ lines; diameter through the united valves 6 lines.

The test appears to have considerable thickness; the hinge-processes are usually large for so small a species.

Stratigraphical position and Locality. All of the specimens known have occurred in a bed of phosphatic nodules in the Fen-district of Cambridgeshire. The position and organic contents of this bed have been investigated by palæontologists connected with the University of Cambridge, and have been referred by them to the Lower Greensand; the results of their observations are embodied in several descriptive notices in the 'Geological Magazine' from 1866 to 1868 inclusive, consisting of communications by Mr. J. F. Walker, Mr. H. Seeley, and Mr. H. Keeping; to the

first of these gentlemen I am indebted for the loan of good illustrative specimens, and also for the subjoined note descriptive of the geology of the Upware district.[1]

[1] Upware is situated on the River Cam, about twelve miles below Cambridge; an outlier of the Coralline Oolite occurs here, and the phosphatic bed has been formed on the shore of the Coral Island, from whence a plentiful supply of calcareous matter having been obtained, will account for the vast number of Brachiopoda (about twenty-five species), many of them new, which have been found in this deposit. The phosphate bed is often divided into two or more layers, the "coprolites" in the upper one are lighter in colour, having been acted upon by water, &c.; the shells, &c., proper to the deposit are found more abundantly at the base of the bed; masses of these shells are sometimes found cemented together by calcareous matter. The phosphatic nodules are water-worn, and have been probably derived from the denudation of the Oxford and Kimmeridge clays. Bryozoa, Serpulæ, &c., occur, and some of them have in their growth followed the outline of the nodules, which shows that the nodules have existed in a hardened condition at that period. Besides these nodules and phosphatized shells derived from these clays, several fossils derived from the Coralline Oolite are found; among these are *Diadema pseudodiadema*, *Hemicidaris intermedia*, casts of *Chemnitzia*, &c. Many remains of Fishes occur in this deposit, viz. *Sphærodus gigas*, Ag.; *Gyrodus*, sp.; *Asteracanthus ornatissimus*, Ag.; *Pycnodus gigas*; *Hybodus* (spine and sphenanchis); *Psammodus reticulatus*, Ag.; *Edaphodon*. Of Reptiles—*Pliosaurus*, *Ichthyosaurus*, *Plesiosaurus*, *Dakosaurus*, and *Iguanodon*.

The fossils proper to the bed consist of a friable carbonate of calcium; among the Brachiopoda are *Terebratula Davidsoni*, *T. Fittoni*, *T. sella*, *T. prælonga*, *T. depressa*, *Rhynchonella Woodwardi*, *R. Upwarensis*, &c. Other Bivalves are not very plentiful; among them are *Opis neocomiensis*, *Cardium* sp., *Cyprina* sp., *Pecten Robinaldinus*, *P. Carteronianus*, *P. Cottaldinus*, *P. atava*, *Plicatula Carteroniana*, *Ostrea macroptera*. There are several Gasteropoda. Most of the Sponges which occur at Farringdon are found in this deposit, as *Manon macropora*, *M. porcatum*, *Verticilites anastomosans*, &c. The sections of the deposit vary in different fields. Many *Trigoniæ* were found in the lower part of the first section given.

'Geological Magazine,' vol. iv, *p.* 309, *July,* 1867.—*First field worked.*

		ft.	in.
Surface, black peaty soil, containing bones of Red-deer, Horse, &c. . .	about	1	6
Layer of light-coloured "coprolites"	„	1	0
Sand (called by the workmen "silt")	„	1	6
Vein of dark-coloured "coprolites"	„	0	9
Silt	„	1	6
Vein of dark "coprolites"	„	1	0
Clay (not pierced).			

Section (*Mr. H. Keeping*), *'Geological Magazine,' vol.* v, p. 273, *June,* 1868.—*Another field.*

Non-fossiliferous Gault.
Phosphatic bed in Gault.
Gault, about one foot thick.
Upper layer of Lower Greensand.
Upper phosphatic bed.
Lower Greensand with few fossils.
Lower phosphatic bed of the Lower Greensand, rich in fossils.
Pure Kimmeridge Clay.
Kimmeridge Clay mixed with Coral Rag.
Coral Rag.

The age of the bed is the same as that of the deposits at Potton, Faringdon, and Godalming, viz. Upper Neocomian, containing fossils proper to that deposit, and fossils derived from the denudation of the Kimmeridge and Oxford Clays and of the Coral Rag.

Trigonia Cunningtoni, *Lycett*, sp. nov. Plate XXIII, fig. 11.

Shell ovately trigonal or subtrigonal, moderately convex; its outline forms nearly an equilateral triangle, with the angles rounded; the umbones are submesial, erect, and obtuse; the anterior side is short, its border is truncated or nearly straight; the lower border is gently curved; the hinge-border is nearly straight, sloping obliquely downwards, and forming an obtuse angle with the perpendicular posteal extremity of the area. The area, which is of moderate breadth, forms a considerable angle with the other portion of the valve; it is flattened or slightly convex, having numerous, closely arranged, small, depressed, curved, oblique, scabrous costellæ; there are no traces of carinæ; a simple divisional angle separates the area from the other portion of the surface. The costæ are numerous, closely arranged, depressed, and rounded; they curve obliquely downwards towards the pallial border, and are much attenuated as they approach the oblique divisional or carinal angle; they are traversed by unequal and irregularly arranged horizontal plications of growth, which also pass over the area;[1] each plication as it crosses the costæ forms a line of small, rounded, depressed nodes, the direction of which is horizontal or only slightly curved; fourteen rows are visible upon one imperfect specimen without including others near the umbo where the test has disappeared; the rows are more closely arranged near the lower border, but their relative distances and the prominence of the rows are extremely variable; about thirteen nodes occupy each row of longitudinal plications.

The internal mould is smooth; it is less trigonal than the test; the apices are elevated, erect, and widely separated; the dental impressions are large, and the line that bounds the area is distinct; the pallial border is deeply crenulated.

The height and the length are equal; the diameter through the united valves slightly exceeds half the height.

Our species is readily distinguished from all other known examples of the *Scabræ* by the peculiar aspect of the closely arranged, depressed, rounded costæ, with their rows of small horizontal nodes and transverse plications.

It appears to have been mistaken for *T. Constantii*, D'Orb. ('Pal. Fr.,' pl. 291, figs. 4, 5), and has been thus named in collections; the latter species is much more lengthened transversely, and more ovate; its narrow ridge-like costæ, and area destitute of costellæ, render the ornamentation altogether distinct.

Stratigraphical position and Locality. The specimen with the test partially preserved was obtained by Mr. Cunnington in the Upper Greensand of Devizes, Wilts; apparently no other example is known to have occurred at that locality. The British Museum has several fine specimens from Normandy; these are nearly destitute of the horizontal plications and nodes.

The name is intended as a slight record of my extensive obligations to Mr. Cunnington in the loan *Trigoniæ* of from various formations, but more especially from the Cretaceous Rocks of Wiltshire; the number of specimens figured affords no criterion of the advantages derived from the comparisons of the very numerous forms placed at my disposal; these included every example of the genus contained in a collection very extensive and peculiarly local.

§ VII. Costatæ.

Trigonia costata, *Sow.* Plate XXIX, figs. 5, 6, 7, 8, 9, 10.

Trigonia costata, *Sowerby.* Mineral Conchology, vol. i, tab. 85, p. 195, 1815.
Lyrodon costatum, *Goldfuss.* Petrefacta Germaniæ, tab. 137, fig. 3 *a*, *b*, 1836.
Trigonia costata, *Agassiz.* Trigonies, pl. 3, fig. 11, 1840.
— lineolata, *Ibid.* Ibid., pl. 4, fig. 1-5, 1840 (young example).
— costata, *Deshayes.* Traité élémentaire de Conch., pl. 32, figs. 12-14, 1849.
— — *Quenstedt.* Der Jura, tab. 60, figs. 10-12; also wood-engraving, p. 502, 1857.

Exclude the following figures of *Trigoniæ* attributed to *T. costata :*

Knorr, Versteinerungen, Supplement, tab. 5 *c*, fig. 3, 4, 1772.
Parkinson, Organic Remains, vol. 3, pl. 12, fig. 4, 1811.
Smith, Strata Identified, Cornbrash, fig. 4, 1819.
Young and Bird, Geol. Survey, pl. 8, fig. 19, 1828.
Sowerby, in Grant's Memoir on the Geology of Cutch, Geol. Trans., 2nd ser., vol. 5, pl. 21, fig. 17, 1836.
Ziethen, Petrefacta Wurtemb., tab. 137, fig. 3 *a*, *b*, 1838.
Bronn, Lethæa Geognostica, tab. 20, fig. 4, 1837-8.
Deshayes, Encyclop. Méthod., Supplement, pl. 238, fig. 1 *a*, *b*, 1836-8.
Dewalque et Chapuis, Paléont. Luxemb., pl. 25, fig. 8, 1855.
Pusch, Polens Palæont., tab. 7, figs. 1, 2, 1837.
Goldfuss, var. triangularis, Petrefacta Germaniæ, tab. 137, fig. 3 *d*, 1836-9.
Ib., ib., tab. 137, fig. 3 *c*, 1836-9.
Quenstedt, Der Jura, tab. 67, fig. 13, 1857.
Ib., tab. 45, fig. 15, 1857.

The foregoing list of authorities excludes descriptions which are not accompanied by figures.

In Britain *T. costata* comprehends two varieties, both of which occur together in the Inferior Oolite in its course through the Southern and Midland Counties of England.

The typical form, which is exemplified by a very good figure in the "Mineral Conchology" of Sowerby, pervades various beds of that formation, and also occurs rarely in the southern Cornbrash; nevertheless it is not generally an abundant fossil. Compared with the other variety, which I designate *lata*, it has great convexity; the form is more lengthened or more pointed, and produced at both of its extremities; the area has greater breadth; its surface forms a more considerable angle with the other portion of the shell, so that when a valve is laid horizontally and viewed from above, the area is only partially visible. The variety *lata*, therefore, has the area somewhat smaller, but more expanded, and the siphonal border is somewhat shorter.

The following description is intended to apply to examples of the species generally, and not as a minute delineation of any individual specimen. This is rendered necessary by the fact, that examples of the same variety from a single bed and locality are not precisely alike in their general proportions or in the lesser details of their surface ornaments; thus, although considerable differences will be found to exist between certain selected specimens, others intermediate render it difficult to arrange such forms into distinct varieties. The separation here adopted will not, therefore, in every instance appear to be well founded. Our figures will, it is trusted, enable the reader to appreciate this subdivision with greater certainty than would be effected solely by a description.

Diagnostic characters. Shell subtrigonal, very convex near the divisional angle of the valve and near the apex, rather depressed posteally; umbo prominent, pointed, incurved, and somewhat recurved; anterior side little produced, its border truncated, near the base it curves with the somewhat shorter lower border; the superior border of the escutcheon is slightly convex, its posteal extremity forms an obtuse angle with the siphonal border, which has a sinuated outline.

The escutcheon is flattened and slightly depressed; its breadth with the valves united exceeds its length; it is well circumscribed and is traversed by large obliquely diverging varices or costellæ. The area is large and flattened; it has some convexity near the marginal carina in the right valve; its superior half is somewhat concave; its breadth at the siphonal border differs considerably, occasionally it is equal to half the height of the shell; it is bounded by two plicated carinæ, but the marginal carina only has any considerable prominence; it is large; its indentations are closely placed and do not deeply impress it, they pass across the costellæ of the area uninterruptedly, giving a reticulated surface to that portion of the shell. The inner carina is broad and depressed, or in another variety nodose, its plications crossing the escutcheon as small, waved striations.

Each portion of the area has from three to five costellæ, uncertain in size and number; the costella which divides the inner from the outer portion of the area is somewhat the larger, forming a median carina; in the right valve it exists only as one of the four or five outer costellæ which are larger than in the other valve.

PLATE XX.

Fig.

1. *Trigonia tenuitexta*, Lyc. Portland Limestone, Isle of Portland. (Page 90.) My cabinet.

1 *a*. ,, ,, A very young example enlarged one diameter. Portland Limestone, Devizes. Coll. Cunnington.

2. ,, *Joassi*, Lyc. Mould with surface ornaments. Lower Calcareous Grit, Brora, N.B. (Page 82.) My cabinet.

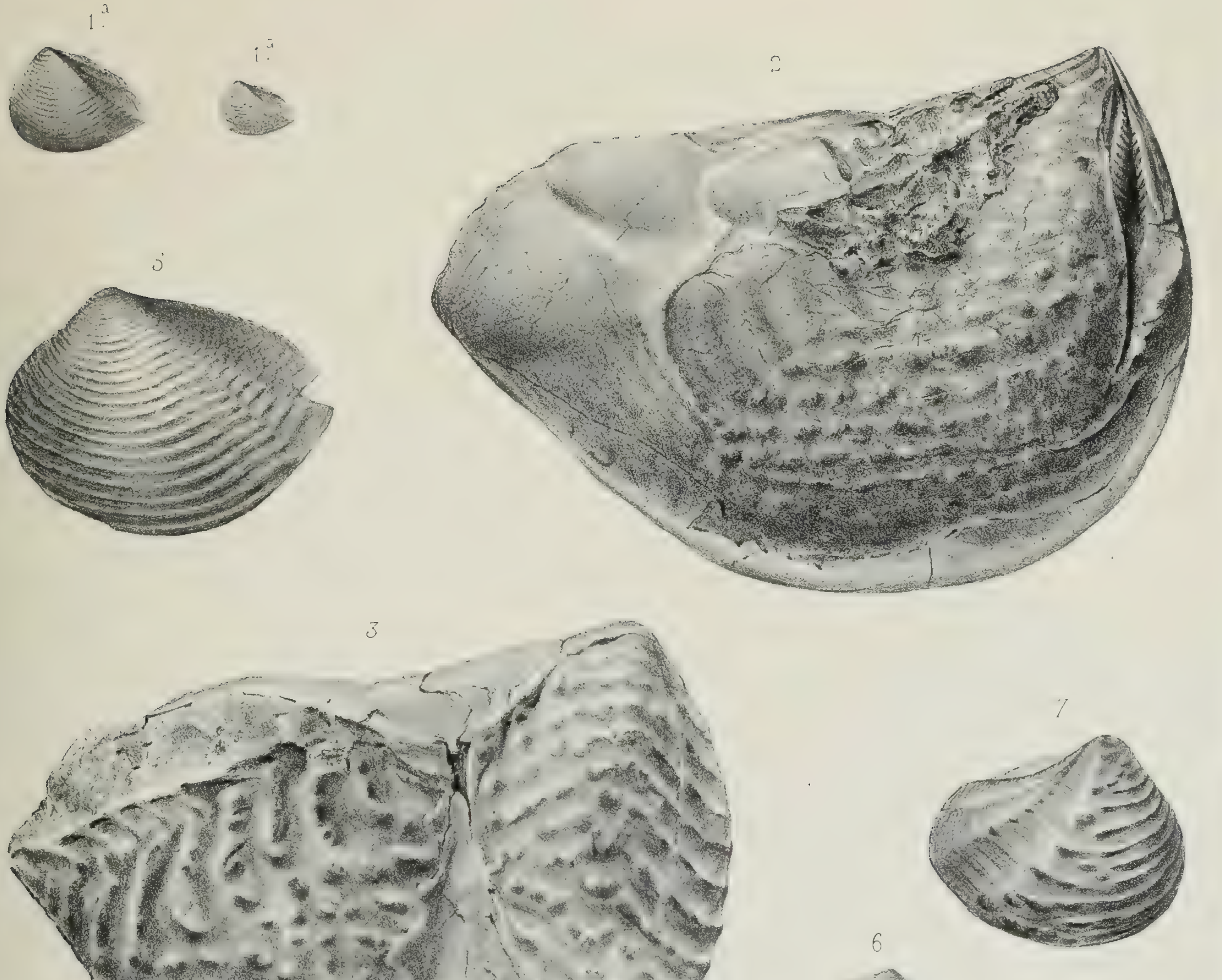
3. ,, ,, Specimen in two portions from the same formation and locality. Coll. British Museum.

4. ,, ,, An entire specimen from the same formation and locality. Coll. Rev. J. M. Joass.

5. ,, *excentrica*, Park. Young example. Blackdown. (Page 94.) Coll. British Museum.

6. ,, ,, A very young example. Greensand, near Collumpton. Coll. Vicary.

7. ,, *Michelotti*, De Lor. (Variety.) Mould of external cast. Portland Oolite, Devizes. (Page 92.) Coll. Cunnington.



Lackerbauer (Karmanski) ad. lap. del.

Imp. Becquet à Paris.

PLATE XXI.

Fig.

1. *Trigonia gibbosa,* Sow. (Variety.) Portland Oolite, Tisbury. (Page 84.) My cabinet.

2. " *Damoniana,* De Lor. Portland Oolite, Swindon. (Page 88.) My cabinet.

3. " " Another example. Portland Limestone, Isle of Portland. My cabinet.

4. " " Another specimen from the same formation and locality; 2 *a*, 2 *b*, upper and anteal surfaces of the same specimen. My cabinet.

5. " " Variety with small costæ and wide ante-carinal space. Portland Limestone, Isle of Portland. My cabinet.

6. " *excentrica,* Sow. Young example. Blackdown Greensand. (Page 94.) Coll. Royal School of Mines.

7. " " An example of fully developed growth. Blackdown Greensand. Coll. British Museum.

Lackerbauer (Karmanski) ad lap. del

PLATE XXII.

Fig.

1, 2. *Trigonia Lingonensis,* Dum. Middle Lias, Eston Nab. (Page 98.) My cabinet.

1 *a*. ,, ,, Area and escutcheon of the specimen fig. 1.

3. ,, ,, Small specimen. Hob Hill Mine, near Saltburn, Middle Lias. My cabinet.

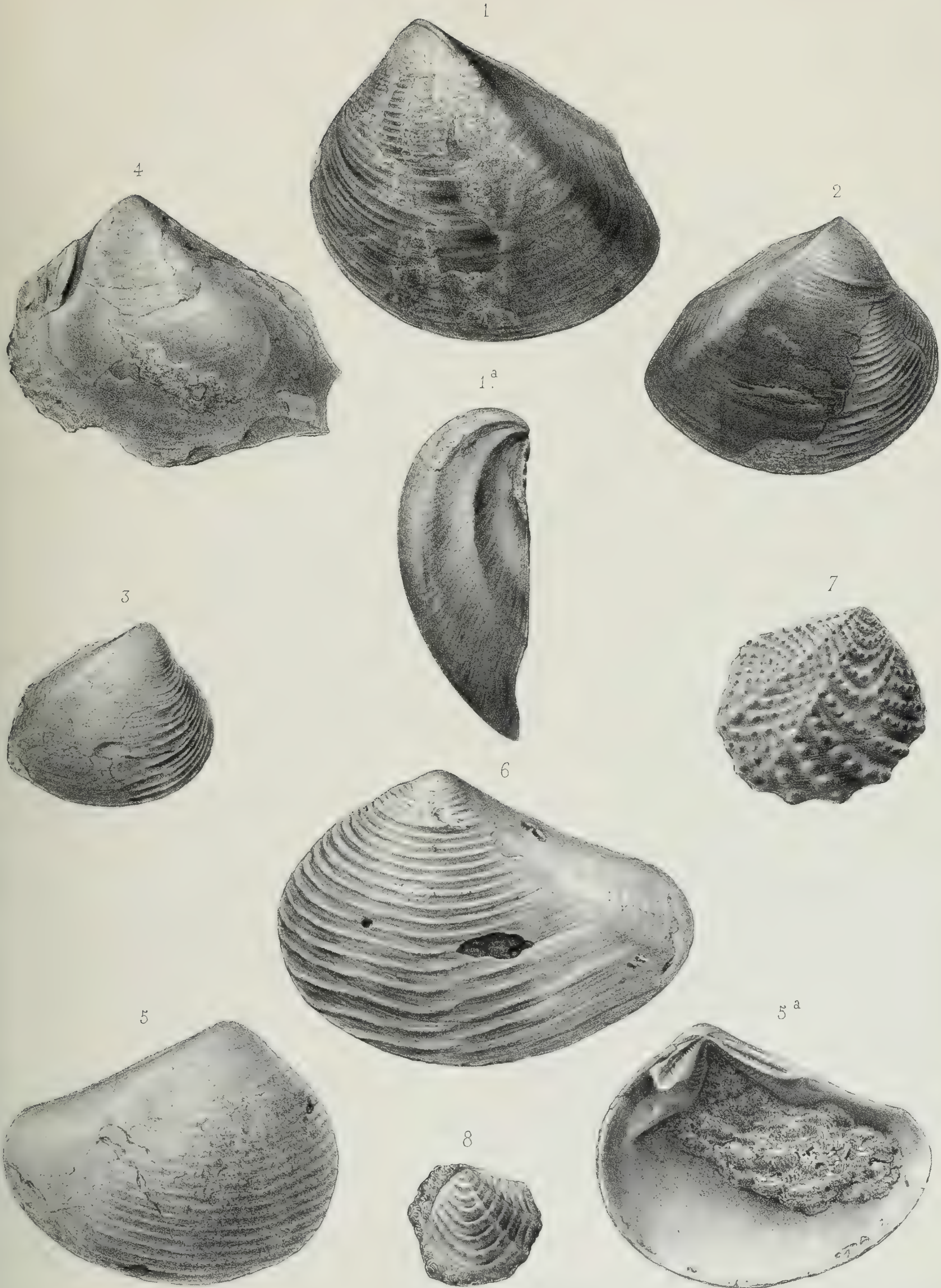
4. ,, ,, Internal Mould, Middle Lias ; Challoner Mine, near Guisborough. My cabinet.

5, 5 *a*. ,, *excentrica,* Sow. Greensand, Blackdown. (Page 94.) Coll. Royal School of Mines.

6. ,, *læviuscula,* Lyc. Greensand, Collumpton. (Page 96.) Coll. Vicary.

7. ,, *dædalea,* Park. Young example. Greensand, Blackdown. (Page 100.) My cabinet.

8. ,, ,, A very young example, slightly magnified, from the same formation and locality. My cabinet. (*T. quadrata,* Sow.)



Lackerbauer (Karmanski) ad. lap. del.

Imp. Becquet à Paris.

PLATE XXIII.

Fig.

1. *Trigonia dædalea*, Park., var. *confusa*. Greensand, Little Haldon. (Page 102.) Coll. Vicary.

2. ,, ,, Large example of the typical form. Greensand, Blackdown, near Collumpton. (Page 100.) My cabinet.

3. ,, ,, Another example from the same position and locality. My cabinet.

4, 4 *a*, 4 *b*. ,, *Fittoni*, Desh. Gault, Folkestone. (Page 132.) My cabinet.)

5. ,, ,, Internal mould from the same formation and locality. Coll. Rev. T. Wiltshire.

6. ,, *Meyeri*, Lyc. Chloritic Marl, near Sidmouth. (Page 125.) My cabinet.

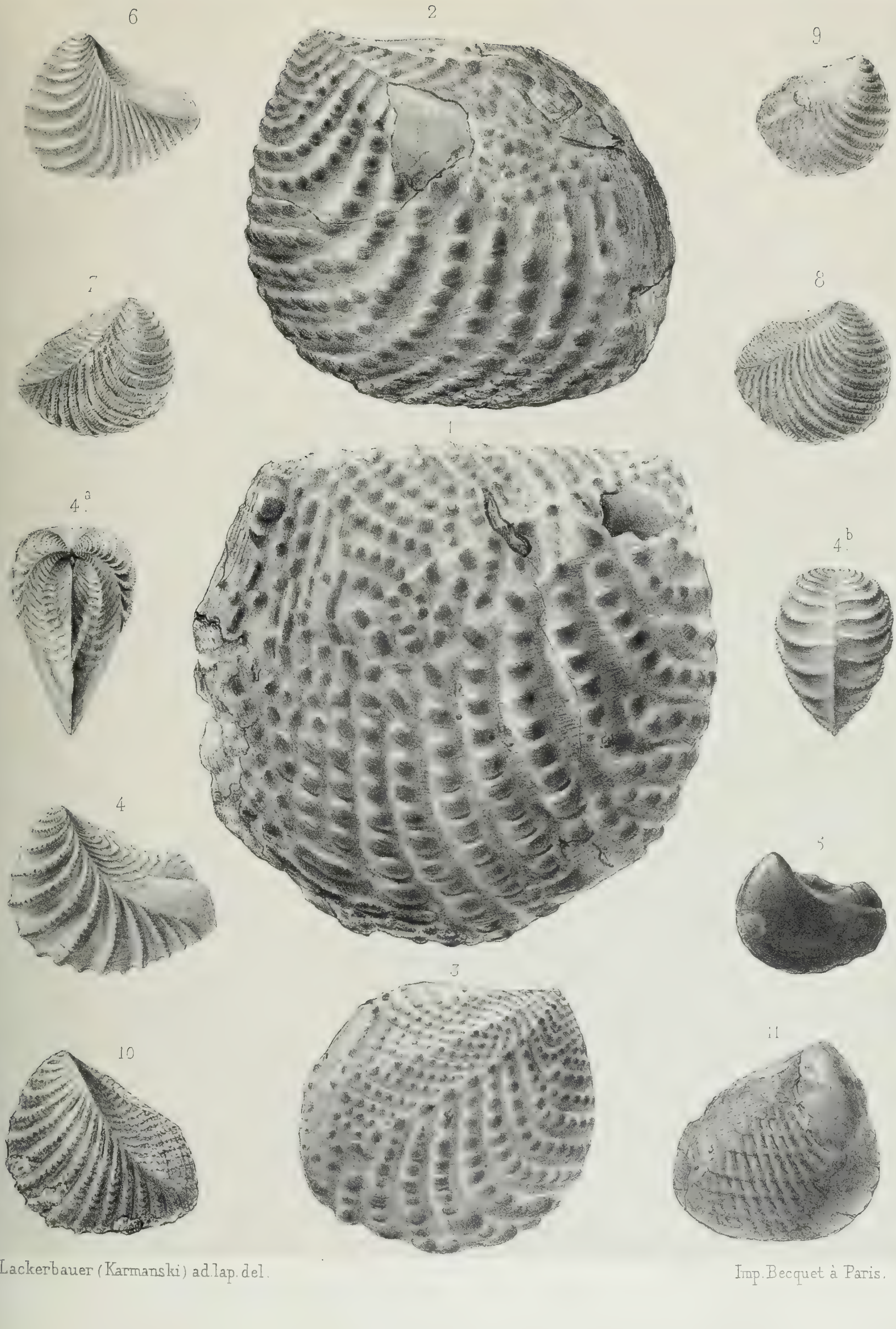
7. ,, *Archiaciana*, D'Orb. Greensand, Blackdown. (Page 140.) Coll. Vicary.

8, 9. ,, *Upwarensis*, Lyc. Neocomian, Upware. (Page 143.) My cabinet.

10. ,, *Spinosa*, Park., var. Upper Greensand, Isle of Wight. (Page 136.) My cabinet.

11. ,, *Cunningtoni*, Lyc. Upper Greensand, Devizes. (Page 146.) Coll. Cunnington.

PL. 23.



Lackerbauer (Karmanski) ad lap. del.

Imp. Becquet à Paris.

PLATE XXIV.

FIG.

1, 1 *a*, 2, *Trigonia nodosa*, Sow., var. *Orbignyana*. Neocomian, Isle of Wight. (Page 106.) My cabinet.

3. ,, ,, Young specimen from the same formation and locality. My cabinet.

4. ,, *pennata*, Sow. Pebble bed, Upper Greensand, Haldon. (Page 133.) Coll. Vicary.

5. ,, ,, Another specimen from the same formation. Coll. Cunnington.

6, 7. ,, *ornata*, D'Orb. Neocomian, Isle of Wight. (Page 139.) My cabinet.

8. ,, *spinosa*, Park. Greensand, Blackdown. (Page 136.) Coll. Rev. T. Wiltshire.

9. ,, ,, Another example from the same formation and locality. Coll. Prof. J. C. Williamson.

10, 10 *a*, 10 *b*. ,, *Vectiana*, Lyc. Neocomian, Isle of Wight. (Page 123.) My cabinet.

11. ,, ,, A large specimen from the same formation and locality. My cabinet.

Pl. 24.

Lackerbauer (Karmanski) ad. lap. del

Imp. Becquet à Paris.

PLATE XXV.

Fig.

1. *Trigonia nodosa*, Sow. Neocomian, Sandown. (Page 106.) My cabinet.

2. ,, ,, Specimen from ferruginous pisolite, Tealby. My cabinet.

3, 3 *a*. ,, *aliformis*, Park. Greensand, Blackdown. (Page 116.) Coll. Royal School of Mines.

4, 4 *a*. ,, ,, Greensand, Blackdown. My cabinet.

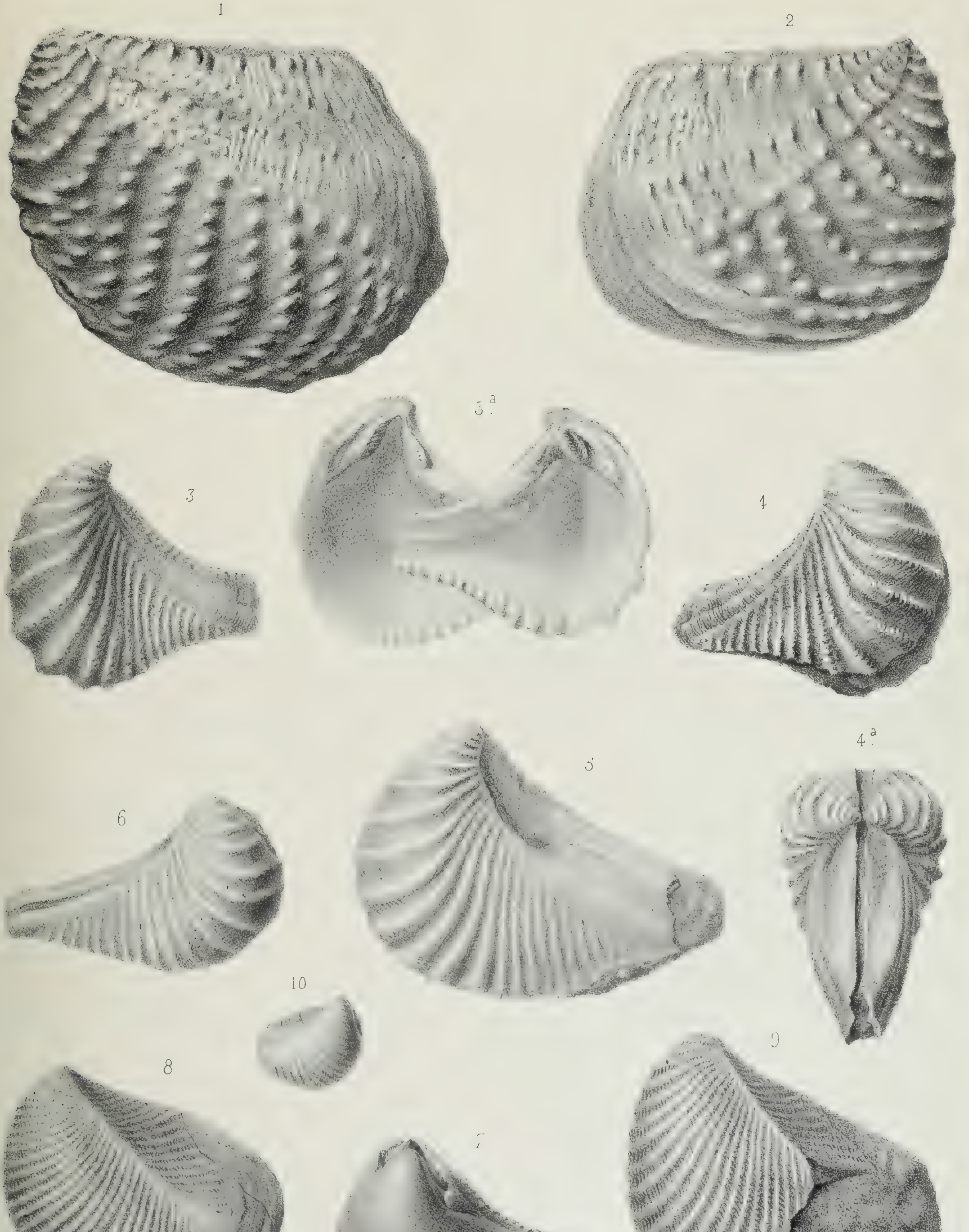
5, 6. ,, ,, variety, *attenuata*. Upper Greensand, Isle of Wight. (Page 118.) My cabinet.

7. ,, *Vectiana*. Internal mould, Neocomian, Isle of Wight. (Page 123.) My cabinet.

8. ,, *Vicaryana*, Lyc. Upper Greensand, near Sidmouth. (Page 141.) My cabinet.

9. ,, ,, Another specimen, having the costæ more widely separated. Pebble bed above the Greensand, Haldon. Coll. Vicary.

10. ,, *Archiaciana*, D'Orb. Specimen deprived of the test. Upper Greensand, Isle of Wight. (Page 140.) My cabinet.



Lackerbauer (Karmanski) ad.lap. del.

Imp. Becquet à Paris

PLATE XXVI.

FIG.

1, 2, 3. *Trigonia spectabilis,* Sow. Greensand, Blackdown. (Page 112.) My cabinet.

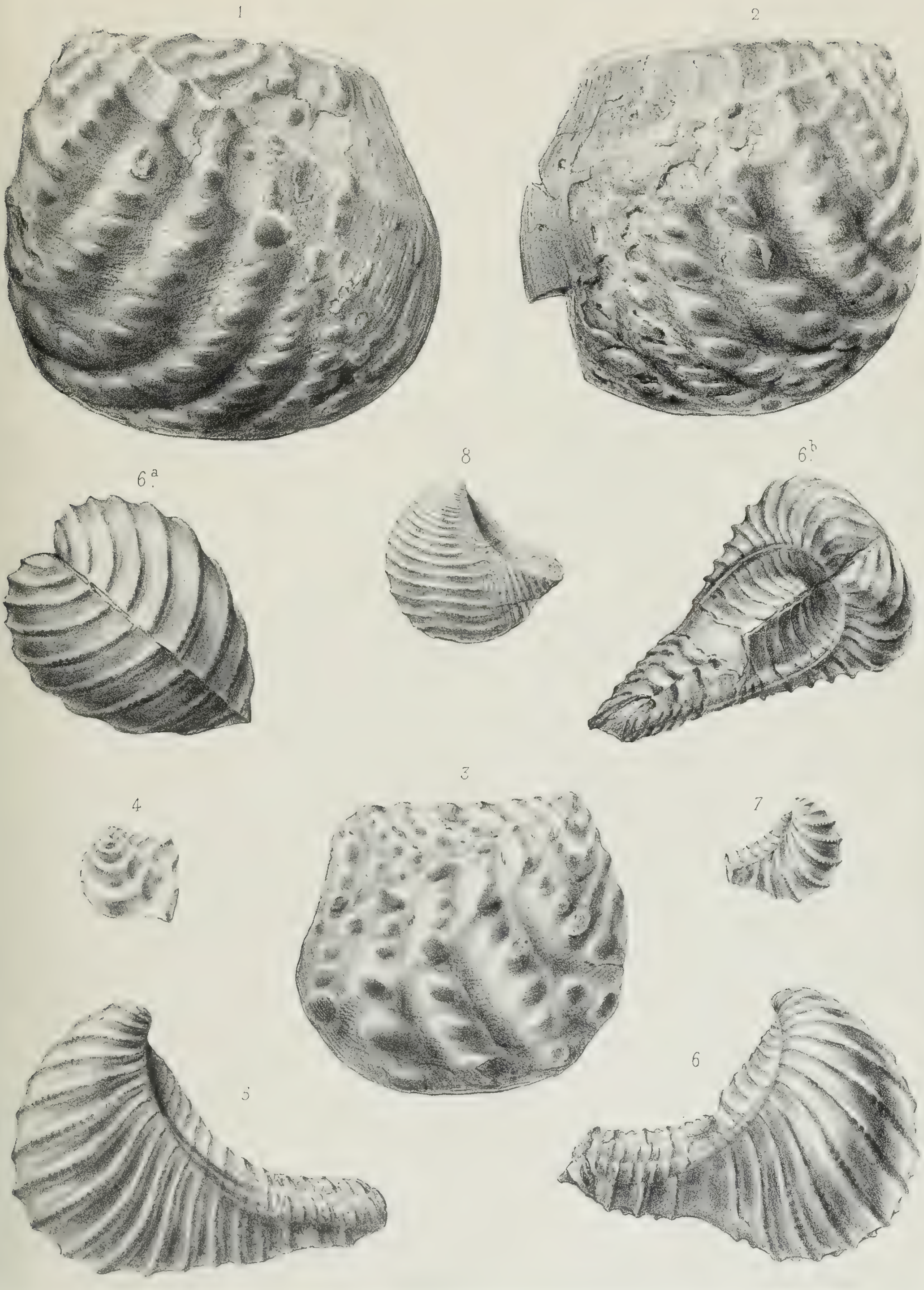
4. ,, ,, Young example from the same formation and locality. Coll. Vicary.

5, 6, 6 *a*, 6 *b*. *caudata,* Ag. Neocomian, Isle of Wight. (Page 129.) My cabinet.

7. ,, ,, Young specimen from the same formation and locality. My cabinet.

8. ,, *sulcataria,* Lam. Pebble bed overlying Greensand, Great Haldon. (Page 135.) Coll. Vicary.

Pl. 26



Lackerbauer (Karmanski) ad lap. del

Imp. Becquet à Paris

PLATE XXVII.

Fig.

1, 1 *a*, 1 *b*, 2. *Trigonia Etheridgei*, Lyc. Neocomian, Perna bed, Isle of Wight. (Page 127.) My cabinet.

3, 3 *a*. „ „ Young example from the same formation and locality. My cabinet.

4, 5, 5 *a*, 5 *b*. „ *scabricola*, Lyc. Greensand, Blackdown. (Page 130.) My cabinet.

PL. 27.

Lickerbauer [illegible] Karmanski [illegible] del

Imp Becquet à Paris

THE

PALÆONTOGRAPHICAL SOCIETY.

INSTITUTED MDCCCXLVII.

VOLUME FOR 1875.

LONDON:

MDCCCLXXV.

MONOGRAPHS

ON THE

BRITISH FOSSIL

REPTILIA

OF THE

MESOZOIC FORMATIONS.

PART II.

PAGES 15—93; PLATES III—XXII.

(GENERA BOTHRIOSPONDYLUS, CETIOSAURUS, OMOSAURUS.)

BY

RICHARD OWEN, C.B., F.R.S.,
FOREIGN ASSOCIATE OF THE INSTITUTE OF FRANCE,
ETC. ETC.

LONDON:
PRINTED FOR THE PALÆONTOGRAPHICAL SOCIETY.
1875.

PRINTED BY
J. E ADLARD, BARTHOLOMEW CLOSE.

MONOGRAPH

ON THE

GENUS *BOTHRIOSPONDYLUS.*

§ 1. BOTHRIOSPONDYLUS FROM THE KIMMERIDGE CLAY.

Species—*Bothriospondylus suffossus*, Owen (Plates III—V).

THE subjects of the first section of the present MONOGRAPH might be deemed to have more interest for the Anatomist, by reason of the singular modification of vertebral structure which they exhibit, than for the Palæontologist, as affording evidence of an additional specific or generic form to the already known numerous extinct Saurian Reptiles of the Mesozoic formations.

The vertebra, for example (Pl. III), which, by the presence of pre-(p) and post-(p') parapophyses with expanded rough syndesmotic articular surfaces, is a sacral one of the Dinosaurian type, presents so singular a degree of depression, or horizontal flattening, of the centrum, as to suggest artificial and posthumous pressure as its cause; and it is true that some of the lumbar or dorsal vertebræ therewith associated show unmistakable marks of such violence. But, as the side view of the present vertebra, Plate III, fig. 4, shows, at c, c', there is no such evidence of fracture of the peripheral compact layer of the bone with distortion, causing more or less departure from symmetry in the centrum, as accompanies every instance of crushing out of shape in the present series of vertebræ (compare figs. 1 and 4, *e.g.*, with fig. 5, in Plate V). There is also evidence of a transitional assumption of the depressed form of centrum, in another sacral one (Pl. IV, figs. 4, 5, 6), which, from having the syndesmosal surface on a single parapophysis (p) on each side, was part of a terminal vertebra of the sacral series.

Four views (Pl. III, figs. 1—4) are given of the vertebral centrum which appears to correspond with that marked 5 in Tab. V of the 'Monograph on the Fossil Reptilia of

the Wealden and Purbeck,' Part IV, Palæontographical Society's Volume for 1856. In the sacrum of the *Hylæosaurus* there figured the vertebra No. 5 offers the greatest breadth and flattening of the under surface, which is also notable for the absence of the longitudinal ridges, parial or single, marking the under surface of the succeeding or preceding centrums.

The under surface of the present sacral (Pl. III, fig. 1) is less accentuated than the Hylæosaurian one compared with it, and the venous canals are relatively smaller than in it: they also issue irregularly, instead of being symmetrically disposed as are the large pair in *Hylæosaurus*. The under surface, as shown in the side view (ib., fig. 4, *c*), is feebly undulate lengthwise, the concave curves being mainly due to the expansion of the articular ends (ib., fig. 3). The under surface of the centrum is as moderately convex across, becoming flat near the free portions of the side of the centrum, (ib., figs. 1, 2, 4, *c'*) and very slightly concave through the distal expansion of the parapophyses (ib., fig. 1, *p p'*). But the distinctive peculiarity of the present centrum from the known sacral ones of other Dinosaurs is the continuation of the free surface, over the side of the centrum (*c'*) between the origins of the parapophyses (*p*, *p'*) into a long, low and deep cavity (ib., figs. 1 and 4, *f*, *f*), overarched by the part of the side of the centrum supporting the neurapophyses (ib., figs. 2 and 4, *np*), which appear to have been confluent therewith, and to have been removed, with the rest of the neural arch, by fracture.

This displacement exposes the floor of the neural canal (ib., fig. 2, *n*), the breadth of which indicates a sacral enlargement of the myelon, and consequent development of the pair of limbs deriving their nerve-supply therefrom. The issue of a large pair of these nerves is indicated by the continuation of the neural surface outward at *o*, *o*, behind the broken bases of the neurapophyses (*np*) which have not extended so near to the end *b*, as to the opposite end, *a*, of the centrum.[1]

Owing to the abrupt continuation of the lateral surface of the centrum into the depressions, *f*, *f*, characteristic of the present genus of Dinosaur, the free surface of the side of the centrum presents the form of a smoothly rounded, longitudinally concave, ridge (ib., figs. 2 & 4, *c'*). It may be that the approximation of the roof and floor of the lateral fossæ has been increased by pressure. Yet the horizontal surface, *f*, could hardly have been bent from the vertical side-surface of the centrum, *c'*, without some fracture of the compact outer layer of bone; and, further, if the flat form of the centrum had been due to such cause, the seemingly natural undulate configuration of the under surface, with its expansion at the two ends, would not have been unobliterated and unmodified in the degree exhibited by the fossil specimen.

The outward production of the fore part of each side of the centrum (fore parapophysis, *p*) has a longitudinal extent of an inch and a half, a vertical one at the articular

[1] Compare the figure of the sacral vertebra of *Iguanodon*, Pl. VII, fig. 4, *o*, *o*, in the 'Monograph on Reptilia of the Wealden,' Part II, in the Palæontographical Society's volume issued for 1854.

surface of seven to eight lines. The surface is rough and slightly concave; it may have contributed less than one half of the vertical extent of the sacro-iliac joint at this part. The fractured or roughened surface above this parapophysis indicates a corresponding diapophysial production of the neural arch for extension of the joint. Longitudinally the pre-parapophysial surface slightly inclines toward the front articular surface, *a*, of the centrum. This surface is flat, very rough, and irregular, indicative of having been broken away from a partial confluence with the opposed surface of a contiguous sacral element; the lower part showing here and there a smoothness as of the original free surface of this end of the centrum. Above this surface large unossified vacuities are shown in the cancellous texture of the bone. The vertical diameter of the articular end of the centrum is one inch three lines; the transverse diameter is three inches six lines. The lower margin is not entire, but has been eroded or worn away for an equable extent of about four lines; along the transverse curve it has not been broken off that end of the centrum.

The post-parapophyses (p') are shorter antero-posteriorly, thicker vertically; and the articular surfaces of this pair converge at a greater angle to the posterior surface, *b*, of the centrum (ib., fig. 3) than in the anterior pair. The upper rough or fractured surface (fig. 3, *n*, *n*) may have coalesced with the fore part of the neural arch of the succeeding sacral vertebra, if such arch, as in other Dinosaurs, has crossed the interval between its own centrum and that of the next sacral. A greater extent of the hinder surface of the present centrum (fig. 3, *c*), at its lower half, shows freedom from anchylosis than on the fore surface.

The Reptile indicated by the portion of the vertebra above described is referable by the characters which such fossil shows to the Dinosaurian group. In the *Crocodilia* the confluent outstanding parts of centrum and neurapophyses, affording attachment to the pelvic arch, are single on each side of the sacral vertebra, and the neural arch retains its normal position in connection with its centrum.[1]

In *Megalosaurus* the lateral abutments for iliac attachments have diapophysial bases, or spring exclusively from the neural arch.[2] Pre- and post-parapophyses are indicated in the sacral vertebræ of *Iguanodon* by the slightly produced or outstanding parts of the side of the centrum articulating with the two displaced neural arches (compare figs. 1 and 2 of Pl. III, with figs. 3 and 4, Tab. VII).[3] In the sacral vertebra of the *Hylæosaurus*, above referred to, the duplex parapophyses have about the same development as in *Bothriospondylus*.

Not any of these earlier described *Dinosauria* have the flattened form and lateral

[1] See Tab. IX, fig. 6, sacral vertebra of *Crocodilus Hastingsiæ*, 'Monograph on the Fossil Reptilia of the London Clay, &c.,' Part II, Palæontographical Society's volume for 1849.

[2] See Tab. I, 'Monograph of the Fossil Reptilia of the Wealden and Purbeck Formations,' Part III, Palæontographical Society's volume for 1855.

[3] Monogr. cit., Part II, Palæontographical Society's volume for 1854.

cavities characteristic of the sacral vertebræ of the present genus; in which I infer, from the different relative expanse of the neural canal, as shown in the figures of the vertebræ above compared, that the hind limbs were relatively less in *Bothriospondylus* than in *Iguanodon.* They, probably, came nearer to Crocodilian proportions.

A second more mutilated sacral centrum of *Bothriospondylus* (Pl. IV, figs. 4, 5, 6) shows the modification of that marked 4 in the sacrum of *Hylæosaurus*, Tab. V, figs. 1 and 2, Monog. cit., in having the parapophysial expansion limited to one (*p*) on each side of the centrum. In the present genus its base occupies the anterior half of the lateral surface, instead of the smaller proportion shown in *Hylæosaurus;* it is also more depressed, and the entire centrum is flatter, though not in so great a degree as in the subject of Pl. I above described. Both ends of the present centrum are flat, and show a greater proportion of the smooth unconfluent condition than in the subject of Plate III, fig. 3. The supporting parts of the neural arch forming the roofs of each lateral cavity (figs. 4 and 5, *f*) are broken off together with the arch itself, and but a small part of the neural surface (ib., figs. 4 and 5, *n*) is preserved.

This mutilation exposes the whole depth of the lateral excavations (fig. 4, *f*, *f*) of the centrum, undermining, as it were, the base of the neural arch; and these show that the breadth of the centrum beneath that arch is reduced, about midway between the two ends, *a* and *b*, to half an inch, the breadth of the centrum at the fore end, *a*, being, when entire, 3 inches 3 lines. At the opposite or hinder end the breadth was less, and the height apparently greater, whence it may be inferred that this vertebra was near to the hinder end of the sacrum.

The right half of the anterior, flat, smooth but irregularly indented, articular surface of the centrum is nearly entire. Extending, as far as the origin of the pre-parapophysis, *p*, which is preserved, and wanting only part of its upper surface, the entire transverse extent can be estimated, as above noted.

The under surface of the centrum (ib., fig. 6) is more convex across than in the subject of fig. 1, Pl. III, concomitantly with its greater extent in the present vertebra. The longitudinal contour of the under surface (Pl. IV, fig. 5) is more uniformly concave. The margin of both articular ends is eroded. The aperture of the lateral excavation (ib., fig. 4, *c'*) is 1 inch 5 lines in longitudinal extent; but the cavity is continued 10 lines further above the pre-parapophysis (ib., *p*); the depth of the excavation at the middle of the vertebra is 1 inch 3 lines. The smooth compact crust of the centrum passes, without fracture, over the free lateral tract (ib., fig. 5, *c'*). The vertically convex border of the floor of the cavity is somewhat thicker than in first-described sacral vertebra, but similarly shows a natural condition and contour. The upper surface of the floor of the cavity shows a fine crack (outside the letter *f* in fig. 4) as if the inner half of that floor, with the adjoining part of the centrum (*p*) supporting the base of the neural arch had been slightly depressed.

The proportion broken away from the left side of the present vertebra is indicated in outline in figs. 4 and 6.

The subject of figs. 1, 2, 3. Pl. IV, transmitted at the same time with the vertebræ above described, and from the same locality, I refer, from the superficial characters of the under and one of the terminal surfaces of the centrum, to the same genus and species of *Dinosaur*, and it probably formed part of the same individual.

The flattened surface of the centrum, at *a*, fig. 2, in the irregular impressions of its otherwise smooth surface closely accords with the one, *b*, of the subject of fig. 5, to which it adapts itself sufficiently closely to suggest that it may have been ligamentously articulated thereto. The opposite surface (ib., fig. 1 and fig. 2, *b*) is not so impressed, is slightly convex and smoother, and indicates a joint with the succeeding vertebra admitting of more movement. I infer, therefore, that the present specimen is the centrum of the last sacral vertebra, and that the end articulating with the first caudal vertebra had resumed more of the usual vertical proportions of the centrum. The parapophysis (*p*), with the irregular syndesmosal surface, has a greater extent, both vertically and lengthwise. Above it extends the narrow fractured surface of the broken off base of the neurapophysis. The floor of the neural canal (fig. 1, *n*) is preserved, which is concave lengthwise as well as across, sinking somewhat into the substance of the centrum. Its diameter midway between the two ends is 7 lines.

The lateral excavations of the centrum appear to have ceased at this vertebra, and probably were not resumed in the caudal series. It has been fractured and somewhat distorted by posthumous violence: but this has not affected the contour of the under surface of the centrum (ib., fig. 3), or the vertical proportions of this element, any more than in the case of the two previously described sacrals.

In four centrums of dorsal or dorso-lumbar vertebræ of *Bothriospondylus suffossus*, forming part of the same series transmitted from the Kimmeridge Clay of Swindon, the characteristic excavations are conspicuous and with longer apertures than in the sacral vertebræ, where these are interrupted by the broad articular parapophyses. No trace of the latter processes are present in the trunk vertebræ of which the type is selected for the subjects of Plate V.

The centrum is subcompressed (fig. 2); its sides moderately concave lengthwise (fig. 1), with one end feebly convex, *a*, the opposite end rather more concave, *b*. I regard the latter as the hinder one, and the trunk-vertebræ to be, as in *Streptospondylus*, of the opisthocœlian type. The free surface of the centrum is smooth, save near the articular ends, where there are low longitudinal risings and shallow channels, as shown in fig. 1, Pl. VI. The under surface (ib., fig. 4) is perforated by two or more small vascular (venous) canals near the articular ends.

The fore end (ib., fig. 2) has a somewhat irregular surface. The hind one, which has suffered less from compression (ib., fig. 3), shows a similar coarse pitting and rising at the

central part of its surface, the peripheral part being smoother than that at the middle, which has yielded to pressure, the large cancelli there having been crushed in.

The bases of the neurapophyses (Pl. V, *np*), commencing about three lines from the anterior end of the centrum, are continued to the posterior end. They have been anchylosed to the centrum and broken away. Posthumous pressure has crushed this specimen laterally and obliquely. Part of the floor of the neural canal is exposed (at *n*, *n*, fig. 5), and is continued outward, at *o*, where the spinal nerve has had issue. The narrowness of the tract of the centrum, between the lateral excavations, *f*, *f*, giving support to the coextensive parts supporting the neural arch, is a singular characteristic of the present genus, and made it difficult to conceive that a mere plate of bone like that between *f* and *np* in fig. 1, Pl. V, would relate to the support of a neural arch. It recalled the structure of that part of the vertebræ in the thoracic-abdominal region of a *Chelonian*. What the character of such arch may have been we have yet to learn, in the present species, from better preserved specimens. Not a fragment recognisable as belonging to such portion of the vertebra could be found among the fossils sent up from the Kimmeridge locality at Swindon.

Two rather more crushed and distorted centrums show, nevertheless, an increase of transverse diameter indicative of their having come from a region of the spine near the sacrum. The centrum shows the same opisthocœlian type, the same wide and deep lateral excavations, undermining, as it were, the neural arch, an absence of transverse processes, and the fractured bases of anchylosed neurapophyses.

The "Swindon Brick and Tile Company's Works," whence, through the kindness of the managing director, James K. Shopland, Esq., the above-described fossils were obtained, are situated on land adjoining the Wilts and Berks Canal. The vertebræ were found, associated with remains of *Pliosaurus brachydeirus*, in the Kimmeridge clay, at a depth of fifteen feet. The clay here is of a deep black-blue; and a mass of lignite, seemingly derived from a crushed trunk of a tree, and burning like ordinary coal, was here discovered.

I was indebted to Richard Jefferies, Esq., of Coate, Swindon, for the first intimation of this discovery, and for a sketch of part of the mandible, 4 feet in length, and of a femur 1 foot 1 inch in length, of the *Pliosaurus ;* of which Sauropterygian genus an entire tooth, and parts of others, with fractured vertebral centrums, were exhumed from the same pit as contained the vertebræ of *Bothriospondylus*. To Mr. Shopland I am indebted for the transmission of the series of specimens here obtained, which included the evidences of the Dinosaurian genus above characterised. This genus, or type of vertebræ, I next proceed to illustrate by larger fossils from other localities and Mesozoic formations.

§ 2. Bothriospondylus from the Forest-marble.

Species—*Bothriospondylus robustus*, Ow. Plate VI.

Of the two extinct Crocodilians from the Oolitic deposits (probably corresponding with the Oxford Clay) in the vicinity of Honfleur and Havre, of which the jaws and teeth are figured in Pl. VIII of the 2nd Part of the fifth volume of Cuvier's 'Ossemens Fossiles,' 4to, 1824, one in which the fore-part of the centrum was convex and the hind-part concave, and to which H. v. Meyer afterwards attached the generic name *Streptospondylus*, was also characterised by lateral depressions (tom. cit., Pl. VIII, fig. 13).[1] I have figured a vertebra of this type, from the Lias of Whitby, under the name of *Streptospondylus Cuvieri*. Assuming the accuracy of the ascription of this type of vertebra to the associated jaws and teeth at Honfleur, the genus *Streptospondylus* is a crocodilian one, and the sacrum would accord with the characters of the order.

I have long had or known evidences of the Reptilian genus characterised by the deep and elongated lateral depressions of the centrum undermining the piers or plates supporting the neural arch. But not until the acquisition from the Kimmeridge Clay of the above-described elements of sacral vertebræ, similarly excavated, were grounds afforded for the determination of the order or group of Saurians to which the *Bothriospondylus* belonged.

The earliest indications of the genus were afforded by fragmentary vertebræ or vertebral centrums from the Forest-marble of Wiltshire, of which the least mutilated is figured in Pl. VI.

It is from the same or contiguous region of the spine as the subjects of Pl. V. The degree of convexity of the anterior surface (Pl. VI, fig. 1, *a*) is the same as that in the subject of fig. 1, Pl. V, *a*. The posterior concavity also shows the irregular tract at the centre, *b*, as in that of *Bothriospondylus suffossus* (Plate V, fig. 3).

The lateral fossa (Pl. VI, fig. 1, *f*), with the same relative longitudinal extent, is somewhat less deep.

The whole centrum is shorter in proportion to its height and breadth than in the subject of Pl. V, fig. 1; it has come not merely from a larger individual of the species, but from another species of the genus, with seemingly a relatively larger, less elongate trunk. This vertebra repeats the textural character of the genus in the unossified proportions of the centrum, causing the large cancelli (Pl. VI, fig. 2) into which spar has infiltrated and crystallised in the fossil. I regard, therefore, the vertebræ from the Wiltshire Oolitic or Mesozoic deposits called 'Forest-marble' as indicative of a species

[1] "Derrière la facette, qui reçoit la tête de la côte, est une fosse profonde." Cuvier, tom. cit., p. 155.

distinct from the smaller kind from the Kimmeridge Clay, and propose to call it *Bothriospondylus robustus.*

It is matter of regret that, as yet, no teeth have been recovered from the Swindon locality of the Kimmeridge Clay which are not referable to saurian genera previously known and distinct from *Bothriospondylus.* But in the course of my work on 'Odontography' I received from an esteemed correspondent and ardent collector of fossils, Mr. Channing Pearce, of Bradford, Wilts, a tooth from the Forest-marble near that town, which I figured in the same plate[1] with that of *Hylæosaurus,*[2] discerning in it an extreme modification of the same type of Dinosaurian dentition. I reproduce the figures from the 'Odontography' in Pl. IX of the present Monograph.

The generic name of the Forest-marble Saurian so indicated was suggested by the heart-shaped form of the crown of the fossil tooth (Pl. IX, fig. 2). The crown, being 1 inch in length, 8 lines in breadth, and 5 lines in thickness, might well have come from the jaw of a Dinosaur with dorso-lumbar vertebræ of the size of that here referred to *Bothriospondylus robustus.* The crown suddenly expands above the neck of the tooth, thins to an edge along the fore and hind border (ib., fig. 3), and contracts to a point or apex, which is sub-obtuse, being somewhat worn in the specimen figured. The enamel has a peculiar character (of which a magnified view is given in Pl. IX, fig. 5), being raised into thin wavy longitudinal ridges with widish intervals where it was sculptured by minute rugæ.[3] The fang or root is cylindrical, coated with smooth cement; the base of this was preserved in the subject of fig. 4, Pl. IX. I have not received any specimen of this kind of tooth, nor any vertebra of the type of that figured in Pl. VI, save from the Forest-marble near Bradford; but Professor Phillips has given a woodcut of a mutilated crown of a similar sized tooth,[4] the best preserved margin of which swells out as in *Cardiodon,* which was discovered associated in the 'Great Oolite' with bones which will be subsequently shown to have the characters of *Cetiosaurus.*

I feel the insufficiency of the present grounds for referring these teeth to any otherwise defined species or genus of Dinosaur. But, if such heart-shaped teeth, with other characters of *Cardiodon,* and especially if *in sitú* in the jaw, or in portions of jaw, should be discovered associated with vertebræ of the Bothriospondyloid type, it may then be a question for the taxonomist whether *Bothriospondylus* should subside as a synonym of *Cardiodon;* unless, indeed, modifications of other parts of the skeleton than are now known of *Bothriospondylus robustus* should be deemed to support a distinct generic name (*Marmarospondylus, e. g.*). Meanwhile it seems to me more convenient to retain the vertebral designation of the genus, as I have next to show that such osseous generic characters were manifested by still larger species from other members of the Mesozoic series.

1 'Odontography,' Pl. 75*a*, figs. 7, *a*, *b*, *c*, *d*.

2 Ib., figs. 6, *a*, *b*.

3 'Odontography,' p. 291.

4 'Geology of Oxford,' 8vo, 1871, Diagram LXXXV, p. 253, "Tooth of *Ceteosaurus.*"

§ 3. Bothriospondylus from the Wealden.

A.—*Bothriospondylus elongatus*, Ow. Plate VII.

Although my opinion of the nature of this fossil, figured in the Monograph on Wealden Dinosaurs, Palæontograph. Soc. Volume for 1854, Tab. X, as "the tympanic bone of an Iguanodon?" was subsequently modified, as is well known to those who sympathised with, and assisted by materials in, the progress of my work on 'British Fossil Reptiles,' the first published opinion (1870) of the vertebral nature of the fossil, as far as I am aware, was that of H. G. Seeley, Esq., F.G.S., to which I shall presently refer, retaining my conviction of the closer agreement of the vertebra in question with the subjects of Plates III—VI of the present Monograph than with those of any volant animal.

The species, *Bothriospondylus elongatus*, is represented by the centrum of a dorso-lumbar or trunk-vertebra, from Tilgate, exceeding in the proportion of length to depth that of *Bothriospondylus robustus* (Pl. VI), in a greater degree than this is exceeded by the corresponding vertebra of *Bothriospondylus suffossus* (Pl. V). The ratio of augmentation of bulk also becomes greater as we pass or ascend from the small Kimmeridgian type to the colossal Wealden form.

The length of the present fossil centrum is eight inches, and it must have been more when perfect, for both ends, and especially the fore or subconvex one, have undergone fracture and abrasion. The fractures at the end, *a*, however, bring to light the unusually large cancelli, some of them admitting the end of the thumb; and this structure, associated with the length and depth of the lateral depression, Pl. VII, *f*, give the grounds for referring the specimen to the genus, or group, *Bothriospondylus*.

The natural surface of the bone is smooth, or finely striate lengthwise, towards the articular ends, as in *Bothr. suffossus*, Pl. V, fig. 1. As in that vertebra, also, the centrum expands to both ends, but less gradually, the contracted mid-part being relatively longer; its transverse section is less cylindrical, the lower surface being more flattened, less convex transversely, and the breadth of the middle of the centrum, 3 inches 6 lines, being greater in proportion to the height measured from the margin of the lateral depression to the under surface, which is 2 inches 6 lines.

The part of the centrum above the depression, *f*, becomes, as in the smaller vertebræ, very thin; and, as with the portion preserved in *Bothriospondylus robustus*, the plate inclines outward as it ascends, indicative of a neural arch of greater breadth than the centrum below.

It may be that the more fragile, or less robust, character of the expanded arch is connected with the loss of that part of the vertebra in most of the examples of the genus of which I have hitherto had cognizance. In *Chelonia* the sides of the neural arches of the abdominal vertebræ are represented by thin vertical plates of bone.

The excavate modification of the centrum of *Bothriospondylus* is more commonly met with in that element of the vertebræ of Fishes, as is also the character of the large proportion of modified chondrine in its substance. In some of the large Scomberoids there is a lower as well as an upper excavation on each side of the centrum.

The bases of the parapophyses of the abdominal vertebræ of the Haddock (*Gadus æglefinus*) are expanded and excavated. Pallas observed that saccular productions of the air-bladder were continued into, and, as it were, lined, homologous cavities at the sides of the trunk vertebræ of an allied Gadoid (*Gadus Navaga*).

As the lateral fossæ disappear in the caudal vertebræ of *Bothriospondylus* one is tempted to surmise that saccular processes of the lungs, which probably, as in *Sauria* and *Chelonia,* lined the mid-part of the roof of the thoracic-abdominal cavity, may have been prolonged into the lateral excavations of the vertebræ. But, if so, the lungs must have extended far forward as well as backward, since posterior cervical or anterior dorsal vertebræ show the lateral fossæ, as do the sacral vertebræ.

In certain *Pterosauria* (*Coloborhynchus Sedgwickii, e.g.*) extensions of the lungs or air-cells were continued along the sides of the neck, and did penetrate lateral depressions of the centrum answering to those in *Bothriospondylus*.[1]

B.—*Bothriospondylus magnus*, Ow. Plates VIII and IX.

That the anterior dorsal vertebra, of which a side view is given of the natural size in Pl. VIII, does not belong to the same species as the previously described centrum from a hinder part of the trunk, may be inferred from the superior proportions of the articular ends to the length of the centrum. On the supposition that the present vertebra formed part of the back-bone of a larger and older individual of the same species as *Bothriospondylus elongatus* it would show a degree of shortness of the centrum in proportion to its breadth and depth, which is unique in my experience of the characters of centrums in the same region of the vertebral column.

A vertebra, as in Pl. VII, with a terminal facet eight inches in vertical diameter,

[1] Owen, "On the Vertebral Characters of the Order *Pterosauria*." 'Philosophical Transactions,' MDCCCLIX, p. 114, pl. x, figs. 5, 7.

would be nearly sixteen inches in length if it came from the spinal column of a *Bothriospondylus* with an anterior dorsal or cervical vertebra of the vertical and transverse dimensions of the subject of Pl. VIII.

I infer, therefore, that this fossil indicates a species with proportions of the vertebræ, and probably of the trunk, more like those deducible from the type of *Bothriospondylus robustus.* But the present remarkable fossil shows a still larger proportion of unossified parts in the substance of the centrum.

The side-pit is short, vertically wide, but deep; the long diameter of the aperture is somewhat more than one third that of the entire centrum: its compact lining layer of bone is entire, not perforated as in the 'foramina pneumatica' of birds. The fore part of this element is strongly convex; the hind part answerably concave. The bases of the neural arch extend to within an inch and a half of the hind margin of the centrum; they rise at the beginning of the convexity of the fore end. This convexity has suffered abrasion, and the widely cancellous structure is exposed, as shown in Pl. IX.

Craving excuse for premising so trite or elementary remarks, the primal basis of the vertebrate skeleton may be converted into sclerine or chondrine, and ossification may begin in either 'membrane' or 'cartilage.' In some Vertebrates, chiefly if not exclusively cold-blooded, more or less of the bone may remaing unossified, retaining the antecedent stage, with some slight modification of tissue, to which, as in Selachian vertebræ, the term 'chondrine' has been specially given.

Such partially ossified bones show corresponding cavities, usually filled with matrix, or spar, in the petrified state.

But this condition of fossil bones may depend on other osteogenetic changes. After substitution of bone-earth for gristle, or the conversion of the entire cartilaginous mould into bone, the central part may be absorbed, and an oily substance called 'marrow' be deposited in the cavity. Or, the absorption of previous solid bone may go further, the marrow may also be removed, the wall of the bone may be perforated or 'tapped,' and air be admitted from a contiguous extension of the lung.

But in cases of petrifaction the non-ossified parts of a bone become filled by the same mineral infiltration, whether the cavities originally contained chondrine, marrow, or air.

The inconsiderate conclusion that fossil bones with large cavities and thin compact walls must have been those of Pterodactyles or of Birds led to the supposition that certain fossil eggs belonged to one or other of these volant classes, the bones of the unexcluded embryo showing the above hollow or tubular character. Such eggs in a portion of stone from a quarry in the Island of Ascension were submitted to my examination in 1834, and I detected among them the characteristic scapula and coracoid of a Chelonian embryo. To the objection against that determination, based on the hollowness of the larger limb-bones associated therewith, I showed, by dissection of a newly hatched *Chelone* preserved in spirits in the Hunterian Museum, that the cavity of such bones had been filled with chondrine, not with air; that the thin outer shell of bone was a transitory

embryonal character, and that the femora, humeri, and other bones became massive and solid in the adult turtle.[1] The earlier stage seems to have been permanent in *Poikilopleuron* and *Bothriospondylus*.

H. G. SEELEY, Esq., F.G.S., the then able "Assistant to Professor SEDGWICK in the Woodwardian Museum, conceiving[2] that the cavities in the osseous tissue of the subjects of Plates VII—IX had been filled with air, affirms them to have been "constructed after the lightest and airiest plan, such as is only seen in Pterodactyles and Birds;"[3] also that "the neck would appear to have been carried erect after the manner of birds;"[4] finally, concluding that "our animal is therefore clearly ornithic,"[5] he concentrates these ideas and stamps them for currency under the generic name ORNITHOPSIS, for such supposed stupendous volant vertebrate. With respect to which the judgment of competent palæontologists may be exercised in considering the applicability thereto of the 'eleventh' of the "Rules for Zoological and Botanical Nomenclature, authorised by Section D of the British Association at Manchester," 'Reports of the British Association for the Advancement of Science,' 8vo, for the year 1842.[6]

[1] See 'Note,' p. 292, of Lyell's 'Principles of Geology,' vol. ii, ed. 1835.

[2] "On ORNITHOPSIS, a gigantic animal of the Pterodactyle kind, from the Wealden," in 'Annals and Magazine of Natural History,' vol. v (4th series), 1870, p. 279.

[3] Ib., p. 280. [4] Ib., ib. [5] Ib., ib.

[6] "A name whose meaning is glaringly false may be changed"—"when it implies a false proposition which is likely to propagate important errors."—Op. cit.

MONOGRAPH

ON THE

Genus *CETIOSAURUS*.[1]

§ 1. Cetiosaurus from the Great Oolite.

Species—*Cetiosaurus longus,* Ow. (Plate X, and Woodcuts 1—10).

Until a comparatively recent period the generic or family characters of the great extinct Cetiosauroid Reptiles were founded on a few scattered bones of the trunk and limbs. The texture of these fossils mainly differentiated them from the corresponding vertebræ and limb-bones of previously determined genera or species of Saurians. No portion of the skull, not one tooth, had been discovered so associated with Cetiosaurian bones, at the date of my "Reports on British Fossil Reptiles,"[2] as to throw any additional light on the ordinal affinities of the new genus. I had not, then, grounds for dissociating it from the Crocodilian group or order. The grand accession of evidences of the osseous framework of one of the species[3] added to the original collection by Buckland, preserved in his Museum at Oxford, by his eminent successor, the late lamented Professor Phillips, by whom they have been instructively elucidated in his excellent work on the 'Geology of Oxford,'[4] has proportionally advanced the means of determining the ordinal relations and affinities of the genus. The inferences which may be drawn in favour of the Dinosaurian

[1] Gr. κήτειος, cetaceous; σαῦρος, Lizard; "Report on British Fossil Reptiles," Part ii, in 'Reports of the British Association,' &c., for the year 1841; also 'Proceedings of the Geological Society of London' for June, 1841 (vol. iii, p. 457).

[2] 'Reports of the British Association for the Advancement of Science' for the years 1839 and 1841.

[3] "*Cetiosaurus longus,*" Ib., 'Report' of 1841, p. 101.

[4] 8vo, 1871.

characters of the sacrum will be subsequently discussed. But the demonstration of the sacral characters of a more recently discovered Cetiosauroid genus, the subject of another Monograph in the present volume, adds to the grounds for referring the type-species to the great Dinosaurian group of Reptilia.

It is characteristic of the accidents that attend the quest and acquisition of the remains of extinct Vertebrates, that skull, jaws, and teeth should have escaped the careful operations to which we are indebted for the present means of restoring both *Cetiosaurus longus* and *Omosaurus armatus.* Of the former reptile a single doubtful and mutilated tooth was all that Prof. Phillips could refer with any degree of probability to that species.

That the side-pits of saurian vertebræ have no essential relation to largely cancellated, pseudo-pneumatic structure of the bones is shown by their presence in the anterior trunk-vertebræ of the genus for which the uniformly close though coarse osseous texture, as in the whale tribe, suggested the generic name *Cetiosaurus.*

The first indication of this type of Saurian was, however, afforded by an inspection of a limb-bone, submitted to me by Dr. Buckland in 1838, when I was engaged in collecting materials for my 'Report' to the British Association "On the Fossil Reptilia of Great Britain." Buckland had referred to this fossil in his 'Bridgewater Treatise,' 1st edit., 1836, in the following terms:—"There is in the Oxford Museum an ulna from the Great Oolite of Enstone" (Enslow probably meant), "near Woodstock, Oxon., which was examined by Cuvier and pronounced to be cetaceous; and also a portion of a very large rib, apparently of a whale, from the same locality."

This limb-bone I could not match with any then known to me in the Cetaceous order. Yet, save a thin compact outer crust, the osseous structure was, where exposed, like that in the humerus of a Whale or Grampus; there was no medullary cavity. In shape the resemblance, though remote, seemed nearest to that of the outer metatarsal of a Monitor Lizard.[1]

Shortly after I was able to differentiate certain saurian vertebræ from those ascribed to the genera *Iguanodon*, *Hylæosaurus, Megalosaurus,* and *Poikilopleuron,* not only by superiority of size, but by differences in form, proportions, and structure.[2] The latter character applied, more especially, to these huge unknown fossil bones in the comparison with *Poikilopleuron,* in the vertebræ of which four-footed reptile ossification is incomplete and large chondrosal vacuities are left in the substance of the centrum, which, in the fossils, become filled with spar.[3]

[1] See 'Monograph on a Fossil Dinosaur (*Scelidosaurus*) of the Lower Lias,' tab. xi, fig. 3 *v*; Palæontographical Society's volume for 1860. Prof. Phillips, who had obtained, in 1870, from the Great Oolite at Enslow, the three metatarsals of each hind foot of a *Cetiosaurus*, wherewith he was able to compare the above fossil long bone, "incomplete at both extremities," considers the determination of it as a metatarsal of large size to be 'probably true.'—'Geology of Oxford,' &c., 8vo, 1871, p. 285.

[2] 'Proceedings of the Geological Society of London,' June, 1841, *loc. cit.*

[3] The chief of these cavities, being in the centre of the vertebræ, was termed 'medullary' (loc. cit.,

From the similarity of texture of the vertebræ of the new genus of Saurian so indicated to that in the limb-bone from "Blechingdon," Enslow, I suggested that it might belong to *Cetiosaurus*.[1] The cetaceous hypothesis of the huge Oolitic Vertebrate was thereupon abandoned, and my determination was adopted in the second edition of the 'Bridgewater Treatise,' and also by Lyell, who gives a reduced cut of the fossil in his 'Manual of Geology,' ch. xx.

In 1848 Dr. Buckland informed me of the discovery of a femur, 4 feet 3 inches in length, which, from the correspondence of its texture with that of the metatarsal from Blechingdon, and also with that of some fragmentary long bones from Blisworth, Northamptonshire, I referred to the genus *Cetiosaurus*, and to the species from the Great Oolite called *Cetiosaurus longus*.[2]

More recently (1868—70) a considerable proportion of the skeleton has been discovered in the quarries of the Great Oolite of Enslow Rocks at Kirtlington Station, eight miles north of Oxford, the bones of which more nearly approach in size to the type specimen of *Cetiosaurus longus*.[3]

Such of the trunk-vertebræ as were sufficiently entire appear to have come from the fore part of that region, and show the opisthocœlian character of those vertebræ as in certain Dinosaurs. I, therefore, visited Oxford for the purpose of studying these remains.

In the best preserved anterior dorsal vertebra the parapophysis, short but large in vertical extent, shows remains of the articular surface for the head of the rib. The diapophysis, supported by a strong buttress-like ridge, is directed upward and outward at an angle of 45° with the neural spine. The distance between the articular surface for the 'tubercle' and that for the 'head' of the rib is ten inches, which gives the extent of the 'neck' of the rib at this fore part of the thorax. The neural spine is strengthened by lateral buttress-like ridges rising from the neural platform; it is of a massive quadrate form and seems to have terminated obtusely. The zygapophyses are supported by buttress-like vertical ridges.[4] All the characters of this massive vertebra bespeak the great strength of the back-bone of the enormous saurian. The total vertical extent of the above vertebra, which is incomplete at the wider part of the centrum, is 2 feet 4 inches; the breadth at the diapophyses is 1 foot 6 inches.

The vertebra which is the subject of Plate X, from a hinder position of the trunk than

p. 459); but I have since had reason to conclude that it was occupied in the living Saurian by unossified chondrine.

[1] 'Report,' *ut supra*, p. 101.

[2] Ib., ib.

[3] "Vertebræ 8, 9, and 11 inches in diameter," "monstrous ribs," "femora upwards of 5 feet in length."—'Athenæum,' April 2nd, 1870.

[4] "On *Cetiosaurus* from Oolitic Formations," 'Proc. Geol. Soc.,' 1841, l. c., p. 459. *Cetiosaurus longus* is defined as in the 'Report,' and distinguished from the *Cetiosaurus brevis* of the Wealden Formations, pp. 101, 102, which will probably prove to be referable to a distinct cetiosauroid genus.

the above-described, exemplifies the cetiosaurian characters of texture (fig. 2, *p*) also of a contracted antero-posterior extent of the neural arch as it rises from the centrum,[1] and of a partial subsidence of the anterior ball.[2] This vertebra has been crushed and fractured; the right side is pressed obliquely backward for an inch or so beyond the left side, so that the length of the centrum, measured as it has been squeezed out of shape, exaggerates its original or natural longitudinal diameter. This would not exceed, according to my estimate, eight inches. The vertical diameter of the centrum has also been pressed down beyond its original extent. I put the ball or fore part at $6\frac{1}{2}$ inches, the cup behind at 7 inches, in height. The neural arch, as in the type-vertebræ of *Cetiosaurus longus*,[3] is retained in anchylosed union with the centrum to the extent shown in Plate X, viz., eight inches.

A vertically grooved median ridge appears to commence at the back part of the base of the spine. This process is wanting; it probably would have added a foot to the present vertical extent of the vertebra, which is sixteen inches. Minor projecting parts have been equally broken away, and, as usual, lost in the quarrying or extricating operations. Such fractures occur on both sides of the prominent rim of the hinder cup of the centrum (as at *p*, fig. 2, Pl. X). The singularly naturally compressed upper and middle part of the centrum (ib. *f*) underlying the neural canal and forming a vertical plate or medial wall of bone, three to four inches in height, and but six lines to eight lines in thickness, has been in part broken away, exposing that canal. The fore and hind outlets of the neural canal are squeezed into a narrow, vertically lengthened, oval shape (ib., fig. 2, *n*).

The neurapophysis rises by two buttress-like columns (*n*, *n*) which converge as they ascend and overarch the lateral depression *f*. The base of the neural arch is co-extensive with the centrum, save in so far as the anterior ball may have projected beyond; but the neurapophysis soon shows, as it rises, the 'short antero-posterior extent,' which is among the characteristics of the genus.[4] One advantage of the fractures, which must otherwise have been got by sections, is the demonstration of the

[1] In the account, illustrated by woodcuts, given by Phillips in his excellent 'Geology of Oxford,' pp. 246—294, a vertebra, supposed to be lumbar, the subject of the diagram lxxxviii, p. 257, has assigned to it the following admeasurement:—"Greatest length from front to back (crushed) 4·6 in." I have found no trunk-vertebræ of the *Cetiosaurus* from the Kirtlington Oolite so short as this.

[2] In a former 'Monograph' I remark:—"If, as is very probable, the cervical and anterior dorsal vertebræ above described (pp. 22—26), and provisionally referred to *Streptospondylus*, belong to the same reptile as the succeeding vertebræ, here referred to *Cetiosaurus*, we should then have a gigantic Crocodilian of the peculiar transitional type, as between that order and the Dinosaurian, which is manifested by the "Second Honfleur Gavial" of Cuvier, *i.e.*, with convexo-concave vertebræ at the fore part of the trunk, graduating into plano-subconcave vertebræ with elevated and somewhat complex neural arches, at the middle and back part of the trunk, and with vertebræ sub-concave at both ends in the tail."—'Monogr. on Wealden Reptilia,' Suppl. II, p. 34, Palæont. Soc. Vol. for 1857, issued 1859.

[3] "In all these vertebræ the neurapophyses are anchylosed to the centrum," &c.—'Report,' p. 102.

[4] Monogr. cit. (1859), p. 27.

cetiosaurian texture of the bone (Pl. X, fig. 2, *p*), as contrasted with the cancellated structure in *Bothriospondylus* (Pl. IX). The resemblance of this close but somewhat coarse osseous tissue to that of cetaceous bone, especially in the larger Whales, and which seems to characterise the whole skeleton of the present genus of gigantic saurians, might well excuse the idea that the huge long bone first observed was cetaceous.

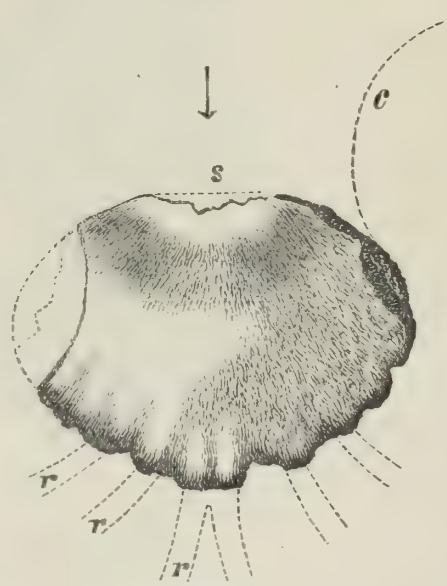
The unbroken surface of the vertebra has a fine fibroid character; the interrupted lines affecting a longitudinal course on the centrum and a vertical one on the neurapophysis. How far any exposure of the arch at the base of the spine may have formed a part answering to the 'platform' in the antecedent vertebra, and as in most Dinosaurs, the broken state of the specimens does not allow of determination.

Near the borders of the articular ends of the centrum, which are more or less rubbed away, stronger sculpturing is indicated, as if in relation to ligamentous attachments.

The lower border of the lateral depression, *f*, is more obtuse, less definite, than in *Bothriospondylus* (Pl. VIII); the vertical convexity of the side of the centrum changes in *Cetiosaurus* more gradually into the concavity of the depression.

The sternum of *Cetiosaurus longus* is a transversely elliptical plate with an almost flat, slightly undulate upper or inner surface (fig. 1); 19 inches broad, 15 inches long, 1 inch to $1\frac{1}{2}$ inch thick, increasing to $2\frac{1}{4}$ inches at the coracoid articular surfaces, though, probably, the entire expanse of the border here is not preserved. The hind border shows prominences for the attachment of three pairs of sternal ribs, the hindmost pair in contact, as in *Monitor niloticus*.

FIG. 1.

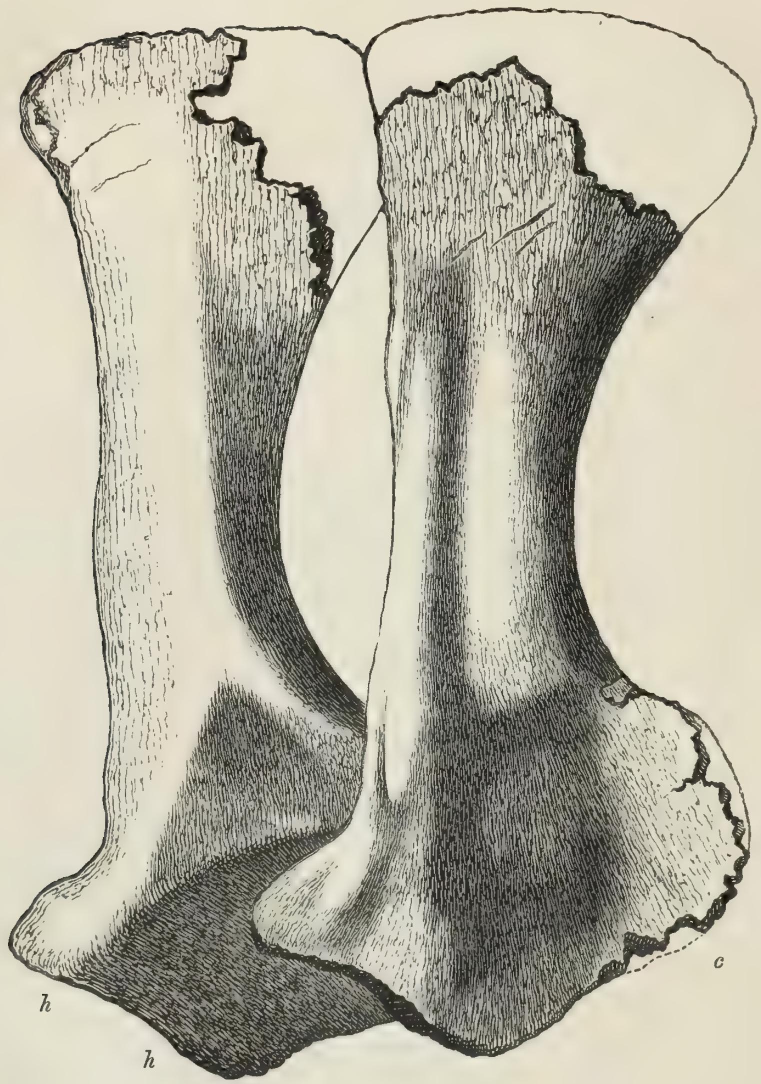


Sternum, *Cetiosaurus longus*, $\frac{1}{10}$th nat. size. (Phps., 'Geol. of Oxford,' part of diagr. xcviii, p. 268.)

In this Lizard the sternum has a rhomboidal form, with a low median ridge on the outer or under surface, a deep hollow on the opposite surface, and considerable thickening of the articulations for the coracoids. Were these bones fully ossified in that Lizard they would correspond in breadth with those of *Cetiosaurus;* there are, however, two tracts retaining the primitive sclerous state, and an antero-medial part which has not gone beyond that of gristle, in the coracoid of the recent saurian. We have, therefore, in *Cetiosaurus,* as in some other ancient saurians, especially *Dinosauria,* a degree of lacertian structure combined with a crocodilian advance of vertebral and concomitant cardiac and pulmonic structures.

The scapula of *Cetiosaurus* (fig. 2) is more crocodilian than lacertian in its

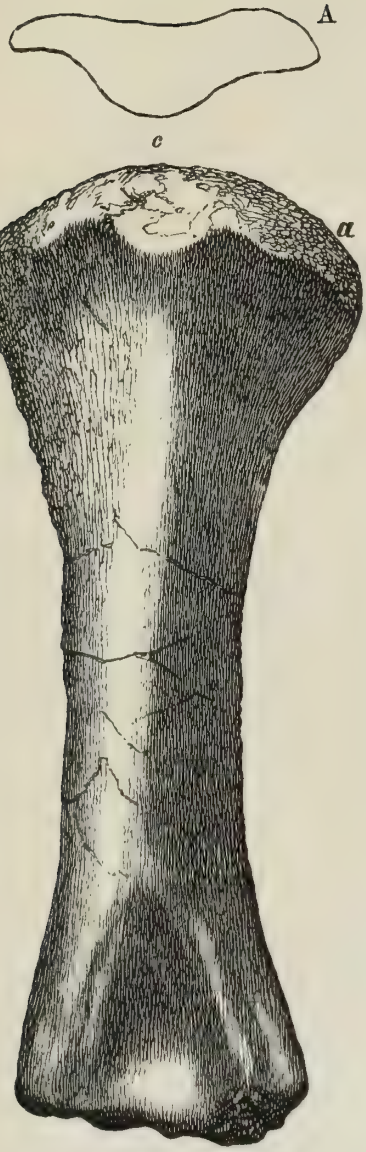
Fig. 2.



Scapula, *Cetiosaurus longus.* $\frac{1}{10}$th nat. size. (Phps., diagr. xcix, p. 270.)

proportions. It is an elongate plate, expanded at both ends, but most so and most abruptly at the articulations for the coracoid, *c*, *c*, and humerus, *h*, *h*. The more gradual expansion of the base or free extremity is chiefly due to the hinder border, and this describes a concavity, while the fore border is nearly straight. The outer surface (left) is slightly depressed lengthwise behind a longitudinal ridge near to and parallel with

Fig. 3



Right.

Fig. 4.

Left.

Humerus, *Cetiosaurus longus*, $\frac{1}{10}$th nat. size. (Phps., diagr. c., p. 272.)

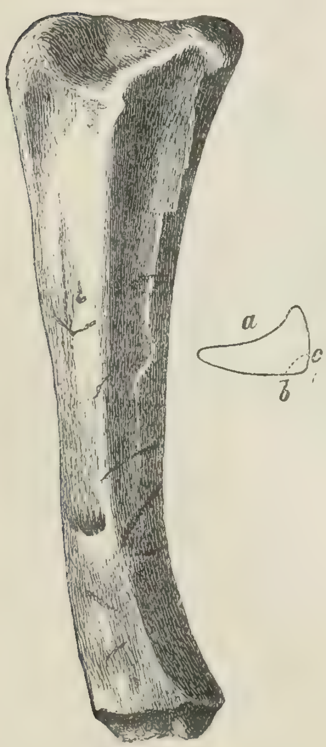
the anterior border. The inner surface (right) has a longitudinal rise near the middle, which bifurcates to strengthen the humeral and coracoid surfaces, and to add to the thickening of the articular end of the bone. Phillips notes the modification of structure of the basal three inches of the blade, indicative of coarse or partial ossification

of an original cartilaginous superscapula, the proportions of which element would thus be more crocodilian than lacertian. The resemblance of the blade-bone of *Cetiosaurus* to that of *Scelidosaurus* has already been noted. But the production of the anterior or humeral angle of the articular end is somewhat greater, approaching that in *Hylæosaurus.* The length of the scapula of *Cetiosaurus longus* is 4 feet 6 inches, the breadth of the articular end is 2 feet 2 inches, the least breadth of the body of the bone 10 inches.

The humerus of *Cetiosaurus* is far from exhibiting the outstanding plates and ridges for muscular attachments, such as we see in the larger existing lizards (*Hydrosaurus, Monitor*), which run swiftly on land; they are even more feebly indicated than in the Crocodiles, but how much of this inferiority may be due to posthumous injury and abrasion in the present huge fossils is questionable.

The head of the humerus, fig. 3, *a*, A, is an elongate, semi-oval, narrow convexity, broadest at the middle, which projects toward the hinder or anconal surface of the bone, as in Lizards and Crocodiles;[1] the degree of the projection is shown in the outline of the proximal end of the bone, at *c*, fig. 3, A.

Fig. 5.



Ulna, *Cetiosaurus longus*, $\frac{1}{10}$th nat. size. (Phps., diagr. ciii, p. 275.)

The ridge from the radial side of the proximal third of the shaft (fig. 4, *b*), answering to the 'pectoral' or 'deltoidal' one in the Mammals, commences, as in the Monitors, near the head, not, as in the Crocodiles, abruptly at some distance below; it has suffered abrasion in the Kirtlington specimen, yet seems not to have stood out in the same relative degree as in the Monitor, in which, as in the Crocodile, it is bent toward the fore or palmar side of the bone.

The shaft of the humerus in *Cetiosaurus* is subcompressed, subtrihedral, through an obtusely angular longitudinal low ridge or prominence, on the anconal side (fig. 3), continued from below the head to near the distal end, inclining toward the radial side. There is no trace of the distal ridge from that border of the shaft which, in Monitors, answers to the 'supinator' ridge in Mammals (Pl. XVII, fig. 6, *e*). The more prominent of the two distal articular convexities, that, viz., for the head of the radius, is feebly indicated; the back part of the convexity for the ulna is traceable at the worn distal end of the bone (fig. 4, *a'*).

The pectoral and supinator ridges are still more feebly in-

[1] 'Supplement (No. III) to Monograph of the Fossil Reptilia of the Cretaceous Formations,' Palæontographical Society's vol. for 1858 (issued 1861), p. 15, tab. iii, fig. 10.

dicated in the humerus of a small or young *Cetiosaurus*, figured by Phillips at p. 273, Diag. CI.

The length of the Kirtlington humerus, figs. 3 and 4, is 4 feet $3\frac{1}{2}$ inches; extreme breadth of the proximal end 1 foot 8 inches; of the distal end 1 foot, 3 inches; diameters at the middle of the shaft 8 inches by 4 inches.

The proportion of the ulna (fig. 5) to the humerus appears to be nearly that in the Monitor. The shaft is more distinctly three-sided, the anconal surface being strengthened by a median longitudinal rising or ridge not present in *Monitor*. As in this Lizard the palmar concavity excavates the whole of the upper half of that surface of the shaft except at the outer and inner ridged boundaries. The margin toward the radius is concave, the opposite one nearly straight, feebly convex. Both ends of the ulna of the Kirtlington Cetiosaur are wanting; it measures in this state upwards of 3 feet in length. In the section, fig. 5, *a*, the palmar side, *a*, is 12 inches across; the facet, *b*, of the anconal side is 11 inches; the narrower facet of the same side, *c*, is 7 inches. No recognisable bones of the fore foot of the *Cetiosaurus longus* appear as yet to have been discovered; but the proportions of the known parts of the fore limbs are such as to make it more likely that they took their share in a quadrapedal mode of progression than that they were borne aloft, with the trunk, on the hind legs like the folded wings of a bird.

The first almost entire femur of *Cetiosaurus longus* was obtained mainly through the personal care and supervision of Hugh E. Strickland, M.A, then (1848) of Merton College, from one of the divisions or thin bands of the 'Great Oolite' underlying the Cornbrash near Enslow Bridge, north of Oxford. At the request of Dr. Buckland I inspected this specimen at the Geological Museum, in the 'Clarendon,' Oxford, and by the light of fragmentary specimens from other Oolitic localities and correspondence of texture with the vertebral bones, especially those from Chipping Norton, I referred it to the *Cetiosaurus medius*. This determination was accepted by Mr. Strickland in his exhibition of the specimen to the Ashmolean Society, March 20th, 1848. The length of this femur is 4 feet 3 inches.

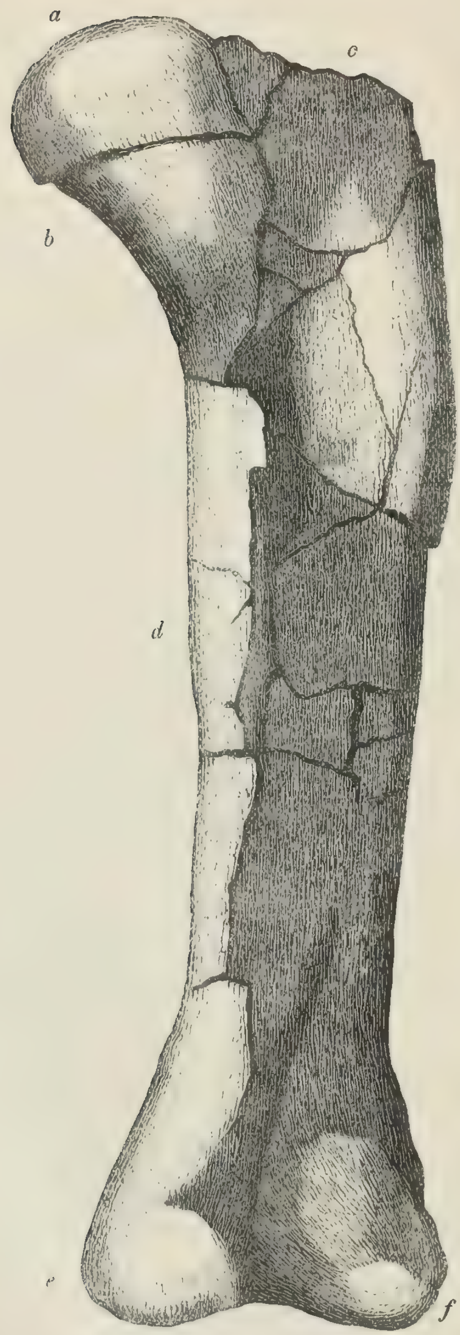
In 1868 the femur of a larger individual of *Cetiosaurus*, and in 1870 other bones with vertebræ answering to those of *Cetiosaurus longus*, were discovered in the same quarries, close to the railway-station for Kirtlington, eight miles north of Oxford. Professor Phillips having notice of the first discovery took the requisite steps, with his wonted energy, to prosecute the quest and secure for his science the evidences of the monster dragon.

The thigh-bone, first come upon, "was found to be lying on a freshly bared surface of the Great Oolite, nearly in the line of a natural fissure, and covered by the laminated clay and thin oolitic bands which there occupy the place assigned to the Bradford Clay of Wiltshire."[1]

[1] 'Geology of Oxford,' p. 247-8.

f

Fig. 6.



Femur, *Cetiosaurus longus*, $\frac{1}{10}$th nat. size. (Phps., cviii, p. 281.)

The femur was 5 feet 4 inches in length. In the course of the quarrying works the opposite femur and many other bones of the same skeleton were brought to light.

The majority of these "did not actually touch the Oolite, still less were embedded in it, though single exceptions occurred of each circumstance" (p. 251).

"The strata covering the solid Oolite were thus noted, March 21st, 1870:
"Thin skerry beds of Forest-marble and shaly clay.

	Ft.	in.
"Band of white calcareous concretions and clay . .	0	10
"Blue and greenish clay with white calcareous spots, and selenite .	2	7
"Brown, yellow, and grey layers, argillaceous, sandy, and oolitic .	1	4
"Grey and argillaceous bed, with selenite . . .	0	2
"Grey and greenish bed loosely oolitic, with *Terebratula maxillata*, *Avicula*, *Astarte*	0	8
"Clay and loosely aggregated oolitic parts, with selenite and abundance of carbonized wood, some shells, and most of the bones .	1	6
"Clay below	0	6

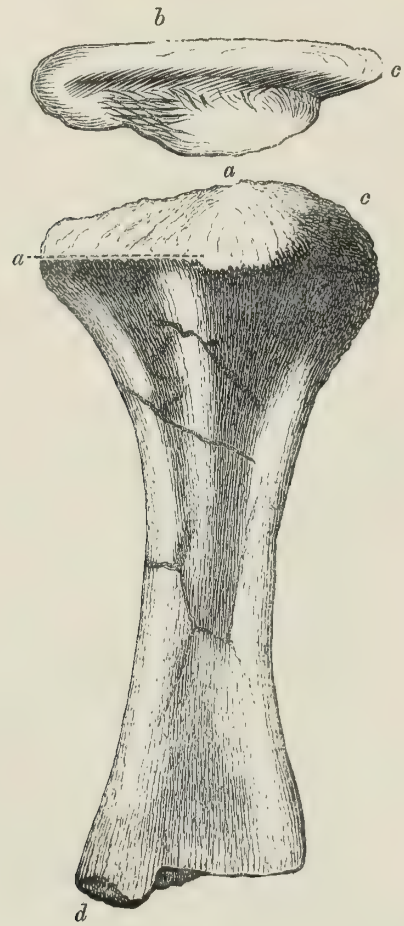
"Great Oolite with undulated and waterworn surface. The two lower bands 'die out' to the southward, and there some of the bones came in contact with the rock, and others were engaged in it." Phillips, ut supra, p. 251.

The most striking of the remains here discovered was the fellow femur (right) of the one (left) found in the previous year. The anterior surface of the latter (left) is shown in cut 6. It is 5 feet 4 inches in length, the diameter of the middle of the shaft is 1 foot, that across the condyles 1 foot 5 inches. The shaft is naturally subcompressed, but the flattening has been exaggerated by posthumous pressure to which the closely cancellated texture of the interior of the shaft has yielded, with fracture of parts of the denser outer crust; but there is no sufficient indication of the head, *a*, having been pressed so as to project inward, from any original disposition of that prominence forward, such as characterises the femur in modern Crocodiles and Lizards. The relation of the head to the shaft of the bone is thus more mammalian than saurian in the gigantic Cetiosaur. But the 'neck,' *b*, is short, or almost nil; the trochanterian angle, *c*, not produced above the level of the neck or head. The trace of any prominence for muscular attachment at the inner part of the shaft, *d*, is feeble; by no means such as appears in *Scelidosaurus* or *Iguanodon*. The distal end expands to the condyles, *e*, *f*, but in a minor degree than in the Monitor.

The cut, fig. 7, shows the postero-external surface of the right tibia of *Cetiosaurus longus*. The prominence, *a*, is that which receives the outer condyle of the femur; the

border, *b*, in the view of the proximal end, gives the contour of the antero-internal part, which is rather flatter than in *Monitor;* *c* shows the production above the procnemial ridge at the fore part of the bone; *d* is the part which was articulated to the distal epiphysis supporting the outer malleolus. The proportions of the tibia to the femur are less than in Monitors or Crocodiles; the length of that (fig. 7) adapted to the femur

Fig. 7.



Tibia, *Cetiosaurus longus*, $\frac{1}{10}$th nat. size. (Phps., part of diagr. cix, p. 282.)

(fig. 6) is 3 feet 2 inches; the breadth of the proximal end is 1 foot 5 inches; of the distal end 1 foot.

As Professor Phillips remarks, "the terminal surfaces are strongly marked by the pitted adherence of cartilage, ... which gives the appearance of deficient epiphyses."[1]

[1] P. 282-3. He adopts an idea that the convex part of the anterior surface of the distal portion of the shaft of the tibia in the Crocodile is the homologue of the ascending process of the astragalus of

In a full-grown *Monitor niloticus* the distal epiphysis, which affords the articular surface to the astragalus, is unanchylosed, the line of suture closely resembling that in the distal end of the present fossil.

Of the foot-bones, "three metatarsals of each foot were secured." The largest appeared to be the first or innermost, the slenderest the third or outermost of the series. "Perhaps there were only three metatarsals, since the specimens we possess exhibit opposite pairs of three and no more" (p. 285).

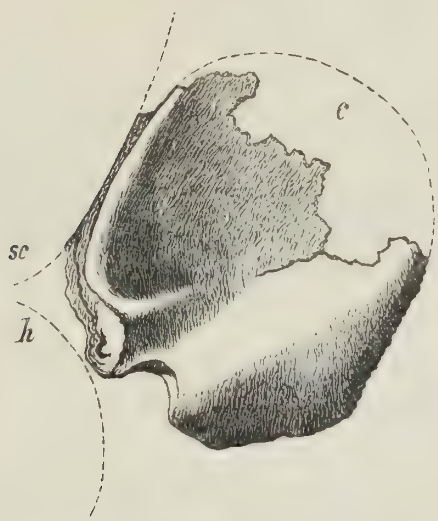
That these bones are homologous with those determined as the second, third, and fourth of the pentadactyle foot in *Scelidosaurus* and *Iguanodon* I deem more probable than that they answered to the metatarsals of the first, second, and third digits in *Crocodilus*.

If a first or a fifth digit existed in the hind foot of *Cetiosaurus*, their shortness or rudimental condition may have prevented their recognition.

In the description of the osseous characters then known of the largest species of Whale-Lizard, I remarked:

"These enormous *Cetiosauri* may be presumed to have been of aquatic and, most

Fig. 8.



Coracoid, *Cetiosaurus longus*, $\frac{1}{10}$th nat. size. (Phps., part of diagr. xcviii, p. 268.)

Megalosaurus, but "separated from its base and anchylosed to the tibia; while in *Megalosaurus* the connection remains, and the ascending process is not joined by synostosis to the tibia" (op. cit., p. 283). *Scelidosaurus* instructively exemplifies the homology of the distal epiphysis of the tibia in Dinosaurs with that in the Monitor and the Bird, and demonstrates the separate existence of the bone answering to the astragalus, &c., in both Crocodiles and Lizards, but which is not ossified in the tarsus of Birds. (Monogr. cit., p. 16, pls. x and xi.)

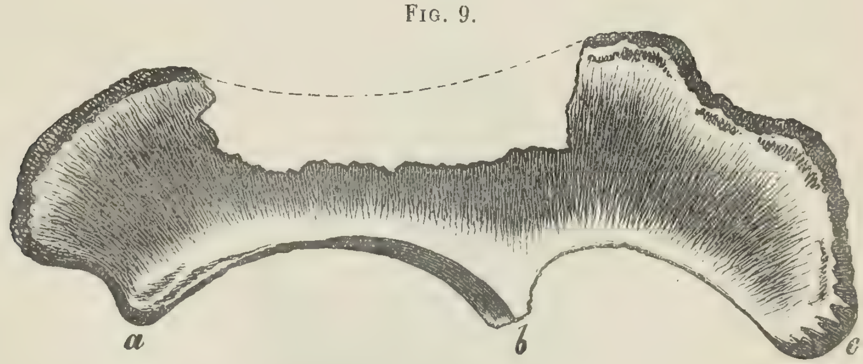
probably, of marine habits, on the evidence of the coarse cancellous tissue of the long bones which show no trace of medullary cavity."[1]

In reference to their affinities:

"In the great expanse of the coracoid [fig. 8] and pubic bones, as compared with the Teleosaur and Crocodiles, the gigantic Saurians in question manifested their closer affinity to the *Enaliosauria*"[2]—closer, that is, than the Teleosaurs or Crocodiles show; but "their essential adherence to the Crocodilian type is marked by the form of the long bones of the extremities, especially of the metatarsals: and, above all, by the toes being terminated by strong claws." Here, in 1842, the clawless character of the limbs of Plesio- and Ichthyo-sauri was the dominant idea, to the exclusion of the then novel group of *Dinosauria*, "characterised by a large sacrum composed of five anchylosed vertebræ of unusual construction," &c.[3]

The question to be determined in respect to *Cetiosaurus* is the admissibility of the genus by the sacral character to the Dinosaurian order. This character, in 1842, I put in the van, relating as it does, physiologically, to terrestrial progression more after the manner of Mammalian quadrupeds than of existing four-footed Saurians, whether Crocodiles or Lizards; an extent of the trunk being thereby transmitted, through a co-extensive ilium, upon hind limbs, the chief bones of which are 'medullary' in *Dinosauria*.

Fig. 9.



Ilium, *Cetiosaurus longus*, $\frac{1}{10}$th nat. size. (Phps., cv, p. 278.)

The ilium (fig. 9) of the *Cetiosaurus longus*, from the Kirtlington quarry, is estimated by Phillips as probably equal to six vertebræ. He writes:

"The extreme length of one (ilium) is 42, of the other 45 inches, probably equal to six vertebræ,"[4] such sacral vertebræ being estimated each at a little over 7 inches in length.

These vertebræ are briefly noticed as follows:—"Several bones of this portion are in the collection, but there is great difficulty in so placing them as to acquire a just notion of the structure or to present a satisfactory drawing. In some degree it (the sacrum) must

[1] 'Report,' *ut supra*, p. 102. [2] Ib., ib. [3] Ib., p. 102. [4] Op. cit., p. 278.

have approached that of *Hylæosaurus*."[1] Perhaps a nearer one would be the sacrum in *Scelidosaurus*.[2]

In either comparison the length of the sacrum is not to be estimated by that of the ilium. In *Scelidosaurus, e.g.*, in which the number of sacral vertebræ is 'four,' the parts of the ilium anterior and posterior to the sacro-iliac symphysis, or surface of junction with such vertebræ, give to that pelvic bone almost twice the length of the sacrum. The length of this part of the spine in *Scelidosaurus* is 10 inches, whilst that of the ilium is 18 inches, " a part, apparently a small one, being wanting from both extremities" of the iliac bone. But, on this basis, we may allow to the ilium of 45 inches length a sacrum of 24 inches, or one of four vertebræ, each 6 inches in length. It is not probable that a saurian with iliac bones between 3 and 4 feet in length, and thigh-bones between 5 and 6 feet in length, would have a sacrum reduced to the crocodilian formula of two vertebræ.

Admitting, then, that more numerous sacrals, such as the Chelonians show, are not the sole and may not be the chief character of *Dinosauria*, and that the generalisation signified by that term is a passing one, denoting a step in the progress of knowledge of the extinct *Reptilia;* and supposing that it should be now limited to saurian genera, combining, with four or more sacrals, the alternating or interlocking arrangement of the autogenous vertebral elements—as in *Bothriospondylus, Megalosaurus, Iguanodon, Hylæosaurus*—the question to be solved is :—" Does such arrangement characterise the sacrum of *Cetiosaurus?*" Have we, in the absence of any certain or definite knowledge of the cranial and dental characters of the genus, grounds for determining its ordinal relations to the Dinosaurs, Crocodiles, Sauropterygians, Ichthyopterygians, Lacertians, &c.? I am disposed to wait for such additional evidence, admitting, meanwhile, the faculty of terrestrial progression in a superior degree to that of the amphibious Crocodiles; nevertheless, the habitual element of the Cetiosaur may have been, and I believe to have been, the waters of a sea or estuary. And I may here repeat the remark on the initial evidence of the species :—" The main organ of swimming is shown, by the strength and texture and vertical compression of the caudal vertebræ, to have been a broad vertical tail; and the webbed feet, probably, were used only partially, in regulating the course of the swimmer, as in the puny *Amblyrhynchus* of the Galapagos Islands, the sole known example of a saurian of marine habits at the present period."[3]

In fact, to the characters of the caudal vertebræ of *Cetiosaurus longus* known to me at the date of the above-quoted 'Report,' viz.—" post-zygapophyses represented by hollow pits," " slight concavity of both articular ends of the centrum, moderate compression of the sides between the expanded ends, which are subcircular,[4] the under surface concave lengthwise,

[1] Op. cit., p. 257-8.

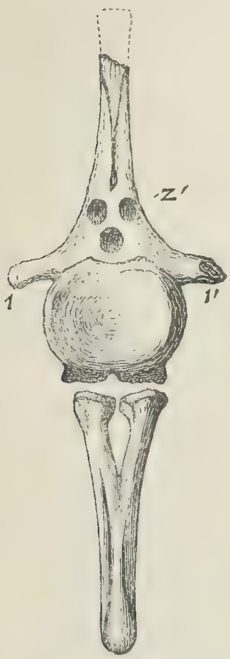
[2] 'Monograph on a Dinosaur of the Lower Lias, *Scelidosaurus*.' Palæontographical Society's volume for 1860 (issued 1863), tab. vi, p. 6.

[3] 'Report,' &c., p. 102.

[4] Ib., pp. 101, 102.

marked by parial articular surfaces, showing the hæmal arches to be articulate therewith over the vertebral interspaces"[1]—the discovery of the grand proportion of the skeleton of the individual at the Enslow quarries adds a demonstration that the hæmal arch in an anterior caudal vertebra (fig. 10) attained a length of 1 foot 2 inches; and that the neural spine "probably rose twelve inches above the canal,"[2] giving a total vertical extent of upwards of a yard to such anterior caudal. The vertebræ probably exceeded in this dimension at the middle of the tail.

Fig. 10.



Caudal vertebra, *Cetiosaurus longus*, $\frac{1}{10}$th nat. size. (Phps., lxxxix, p. 259.)

The modifications of the caudal vertebræ in parts of the tail of *Cetiosaurus longus*, as exemplified by specimens from the Great Oolite described and figured by Phillips (' Geology of Oxford,' 8vo, 1871), are similar to those in the instructively preserved Dinosaur from the Dorsetshire Lias). Compare fig. 2, p. 260 (Cetiosaur), Phps., op. cit., with fig. 1, Pl. VII (Scelidosaur), Ow., Monogr. cit., figs. 1, 2, 3, p. 265 (Cetiosaur), with figs. 1 and 3, Tab. IX (Scelidosaur); and figs. 1, 2, 3, p. 266 (Cetiosaur), with figs. 6, 7, 8, Tab. IX (Scelidosaur).

The broad subquadrate coracoid, with rounded angles, of the *Cetiosaurus longus* from the Enslow quarries (fig. 8) repeats the characters of that bone in the type of the species (' Report,' p. 102). In the Oxford giant the bone measures " from the glenoid cavity to the extremity near the scapular margin (incomplete) 18 inches; if complete, probably 20; breadth between scapular and sternal margins, 18·5 inches; greatest thickness 5·0." (Phillips, op. cit., pp. 270, 271.)

The scapula of *Cetiosaurus* resembles that in *Scelidosaurus,* with rather less concavity of the anterior border, and rather more concavity of the posterior one (comp. Fig. 2, with Monogr. cit., Tab. III, Scelidosaur). It surpasses the humerus in length in a minor degree than in *Scelidosaurus,* and in a still less degree than in *Iguanodon.*

In the characters of the dermo-skeleton *Cetiosaurus* would seem not to agree with *Scelidosaurus.* It is very improbable, if there had been such agreement, that not any skin-scutes or spines should be shown in connection with the large proportion of the skeleton of one and the same individual brought to light on the excavated oolite of Enslow Rocks at Kirtlington.[3]

The same negative evidence in all the various finds of fossil remains on which the genus was based suggested, in 1841, the idea that the tegument of *Cetiosaurus* might be

[1] ' Report,' &c., pp. 101, 102.

[2] Phillips, op. cit., p. 259.

[3] Phillips, op. cit., diagr. lxxxiv, p. 250.

smooth, or unarmed, as in *Cetacea* and *Enaliosauria*. But, as will be shown in the concluding subject of the present contribution to the History of British Fossil Reptiles, a new interest will attach itself to the occurrence of an osseous spine, seemingly dermal, in contiguity with the parts of the fore-limb which were wanting, or not discovered, in the Kirtlington example of *Cetiosaurus longus*.

In *Scelidosaurus* the number of vertebræ between the skull and sacrum is twenty-three or twenty-four;[1] in *Iguanodon* the same region includes more than seventeen vertebræ: in this genus there are five sacral vertebræ: in *Scelidosaurus* four. In no Dinosaur has the number of caudal vertebræ been so satisfactorily or approximately demonstrated as in *Scelidosaurus*. Thirty-five of these vertebræ were obtained in consecutive articular association in the individual which forms the subject of the Monograph above cited. If we allow the Cetiosaur, on this analogy, twenty-four vertebræ between the skull and sacrum, averaging 5 inches each in length, and add an inch for the inter-vertebral connective tissues, we get a total length of trunk at 12 feet. Four sacral vertebræ would add two feet. Taking the number of the caudal vertebræ at that shown in *Scelidosaurus*, and the reduction of length in the ten terminal ones not to be more than is shown in Tab. IX, fig. 2, of the Monograph quoted, the length of the tail of *Cetiosaurus longus* may be set down at 17 feet. Thus we get an approximative idea of the length of this Cetiosaur, *minus* the head, as 31 feet. The fortunate discovery of the skull or lower jaw, or a mandibular ramus, would supply the ground for completing an idea of the size of the whole animal. As the second femur of *Cetiosaurus longus* in the Enslow locality exceeded in size the first, so it may ultimately prove not to represent the extreme size attained by individuals of the species; and the length of 7 inches shown by the typical caudals would found an estimate of 35 or 36 feet for the length of trunk and tail of *Cetiosaurus longus*.

As evidences of this species have now reached me from four counties—Yorkshire, Northamptonshire, Buckinghamshire, and Oxfordshire—I submit that there is no case, according to the 'canons of zoological and botanical nomenclature' adopted by the 'British Association for the Advancement of Science,'[2] for suppressing the original name proposed by the discoverer of the species, and substituting one which is in some degree misguiding. I would also plead for a retention of the orthography of the generic name.[3]

[1] Monogr. cit., p. 11.

[2] 'Report,' &c., for the year 1842.

[3] In framing this name the diphthong in κήτειος was dropped, as in 'pliocene,' 'miocene,' &c.

MONOGRAPH

OF A

FOSSIL DINOSAUR

(*OMOSAURUS ARMATUS*, Owen)

OF THE

KIMMERIDGE CLAY.

§ 1. Introduction.—Having been favoured by James K. Shopland, Esq., Resident Director of the Swindon Brick and Tile Company, to whom the British Museum is indebted for the fossils of *Bothriospondylus suffosus*, described in a previous Monograph,[1] with a note [2] announcing further discovery of larger bones in their Kimmeridge Clay works, followed by a liberal offer on the part of the Company[3] of such of these fossils as might be found worthy of being added to the Geological Collection, Mr. William Davies, of that Department, was instructed to inspect the diggings, and, on his 'Report' of the appearances, was authorised to take the requisite steps to remove and transmit to the

[1] Pal. Monog., 'Mesozoic Reptilia,' "Bothriospondylus," &c., 4to, 1875, p. 15.

[2] "Swindon Brick and Tile Company,
"Swindon, Wilts; 23*rd May*, 1874.

"Dear Sir,

"I last year had the pleasure of sending you some Saurian Remains discovered in this Company's Kimmeridge Clay Pits, and I beg to inform you that we have just laid open other remains considered to be unusually large and fine, which are left *in situ*, carefully covered over.

"As exposure to light and air will, I fear, cause the remains to split and crumble, I should suggest your coming or sending some one to inspect them at once; the clay adjoining I will leave unworked until Wednesday next.

"I am, &c.,
"James K. Shopland.

"Professor Owen, British Museum."

To this 'Note' were added a few lines from E. C. Davey, Esq., F.G.S., of Wantage, Berks, confirmatory of the discovery.

[3] It is due to their enlightened liberality and prompt co-operation in applying to the advance of science whatever, in the course of the works, might aid therein, to subjoin the names of the Directors of the Company:—J. C. Townsend, Esq., Thomas K. Shopland, Esq., Henry Kinneir, Esq., Richard Rowley, Esq.

British Museum as much of the matrix as gave evidence or promise of containing organic remains. This operation was carried out with Mr. Davies' experienced skill and judgment.[1] Some tons weight of matrix was transmitted to the British Museum, and occupied, during the remainder of the year, the practised chisel of Mr. Barlow, the mason-sculptor of the Geological Department, under the guidance and supervision of Mr. Waterhouse, Mr. Davies, and myself. The result was the extrication from these masses of the bones of one and the same individual dragon, or Saurian, and these form the subject of the present Monograph.

They were found at a depth of ten feet from the surface soil covering the clay deposit, which deposit, where it surrounded the bones, presented unusual density and almost intractable hardness, and was traversed by fissures or cavities occupied by infiltrated spar, presenting in parts a septarian character. This condition of the matrix suggested that it might, in some degree, be due to the decomposition and exudation of the soft parts of the large reptile when buried in the clay sea-bed into which it had sunk; gaseous emanations might give rise to fissures or vacuities in the surrounding tenacious mass, into which the stalagmitic spar might subsequently infiltrate during the long ages of the condensation, petrifaction, and upheaval of the deposit; but cracks and cavities, from whatever cause, do become so occupied, as in the present local accumulation, and have received the name of 'septarian doggers.'

In the borings lately carried on at Netherfield, near Battle, Sussex, 660 feet of 'Kimmeridge Clay' were traversed before the 'Oxford Clay' was reached, without interposition of 'Coral Rag' or 'Coralline Oolite.'[2] This testimony to the time during which Kimmeridgian strata had been accumulated to such vertical extent gives free scope for surmise and speculation as to the long ages during which Pliosaurs, Cetiosaurs, Bothriospondylian and other enormous reptiles, lived and died in a world of which they seem to have been masters, as far as grades of organic life and power, acting at that epoch, have been determined. Other lines of variation and modification of the dragon type, besides the new one about to be defined, probably remain to be determined by ulterior research, and to reward the labour, skill, and science of investigators and collectors of Kimmeridgian remains.

Of the Dinosaurian genus and species, for which the name *Omosaurus armatus*[3] is proposed, parts of the vertebral column, the pelvis, a femur, and tibia, and almost all the bones of the left fore limb, have been worked out. The scapular arch, sternum, skull

[1] See the processes described by him in his instructive 'Catalogue of Pleistocene Vertebrata in the Collection of Sir Antonio Brady,' 4to., 1874, p. 71.

[2] A thickness or vertical extent of 1050 feet is assigned to the combined 'upper' and 'lower' divisions of the Kimmeridge Clay, by the Rev. J. F. Blake, M.A., F.G.S., in his instructive memoir on this formation in England, 'Quarterly Journal of the Geological Society,' vol. xxxi, p. 196.

[3] Ὦμος, humerus; Σαυρος, lacertus: suggested by the unusual development of the muscular crests and processes of the arm-bone, perhaps in relation to the formidable weapon with which the fore limb appears to have been armed.

and teeth, and bones of the hind feet, are still desiderata. That not a single tooth should have been met with in any part of the ossiferous matrix is much to be regretted, but one indulges the hope that teeth of *Omosaurus* may be one day recovered and be found implanted in their jaws.

§ 2. Cervical Vertebra.—A portion of a neural arch and spine (Pl. XI, figs. 1 and 2), with the right prezygapophysis, *z*, the left postzygapophysis, *z'*, the roof of the neural canal, *n*, and the entire neural spine, *n s*, might belong, from the shortness of the latter, to a caudal vertebra. But, from the indicated capacity of the neural canal and the aspects of the articular surfaces of the zygapophyses, I infer the specimen to have belonged to a vertebra from the cervical region.

The length of the neural arch is 7 inches 6 lines; the height of the neural spine is 3 inches 6 lines; its fore-and-aft breadth, at the middle, is 2 inches; at the free end 3 inches; the thickness, transversely, is 1 inch: this is at the hind border, near the summit; it slightly decreases toward the base, and the whole spine thins toward the fore part. The summit, which is rugged, gains in extent by being produced backward.

The diameter of the neural canal appears to have been $1\frac{1}{2}$ inches. The prezygapophysis, *z*, projects about half an inch in advance of the base of the diapophysis, *d*, *d*, which here has an antero-posterior extent of 2 inches 6 lines. The outer border of the prezygapophysis is slightly raised above the base of the diapophysis; the articular surface of the prezygapophysis looks upward and slightly inward; it is not quite flat, but feebly convex. The articular surface of the postzygapophysis, *z'*, is in the same degree concave. This surface looks downward and a little outward.

In the figure of the upper surface of a cervical vertebra of a large Monitor Lizard (*Varanus niloticus*, Cuv., Pl. XI, fig. 4) I have indicated by dotted lines the course of the fractures which have reduced the corresponding vertebra of the huge Dinosaur to the condition shown in Fig. 2. The relation of the origin of the diapophysis, *d*, to the prezygapophysis, *z*, is the same in both the recent and fossil Saurian; but the breadth across the zygapophyses was relatively less to the length of the neural arch in *Omosaurus*.

The fragmentary condition of this solitary evidence of the region of the vertebral column supporting the skull seems to point to some strange violence by which the head of the Omosaur has become severed from the trunk, and its frame-work probably borne to some part of the old sea-bed at a distance from the rest of the body.

§ 3. Dorsal Vertebræ.—Amongst the characters of the Order *Dinosauria* is a lofty and buttressed neural arch in a great proportion of the trunk-vertebræ. In former Monographs this is illustrated in the *Iguanodon* (Suppl., No. II, Pal. vol. for 1857, Tab. VII, figs. 4—6); in the *Megalosaurus* (Pal. vol. for 1854, 'Wealden Reptilia,' Tab. XIX); in the *Cetiosaurus* (Suppl., No. II, Pal. vol. for 1857, Tabs. VIII, IX).

This character is strongly marked in dorsal vertebræ of the present genus, and with modifications which could hardly have been illustrated or made clear without the above-cited figures of the vertebræ of previously defined Dinosaurian genera. In these, however, the degree of complexity of the neural platform varies ; it is least marked in the smaller and more crocodilioid genus *Scelidosaurus* (Pal. vol. for 1860, 'Liassic Dinosauria,' pp. 5—7, Tabs. II—VI).

The vertebra of *Omosaurus*—the subject of Plates XII, fig. 1, and XIII—has come from the middle of the trunk. This is inferred from the position of the surface, *p*, for the head of the rib, which has risen from the centrum, or base of the neural arch, to near its summit, where, with its diapophysial productions, *d*, *d*, the arch expands to a breadth of 14 inches 6 lines ; the breadth (in the same direction, transversely) of the centrum being 5 inches 3 lines. The vertical diameter of the middle of the articular surface of the centrum is 4 inches 9 lines ; the height of the vertebra to the base of the neural spine is 11 inches. This spine has been worked out entire only in the above-described cervical and caudal vertebræ ; but there are indications justifying an estimate of its length in the dorsal series, at from 6 to 8 inches.

Thus, the dorsal vertebra, affording material for the present description, which has a breadth, as above shown, of one foot two and a half inches, had a height of at least one foot and a half.

The fore-and-aft dimension of the centrum (Pl. XIII, fig. 3) is 4 inches. The anterior surface (ib., *a*), where it varies from flatness, is toward convexity, but in the feeblest degree ; the posterior surface (ib., *b*) is very slightly, but more equably, concave. The free surface of the centrum is moderately concave longitudinally ; slightly depressed at *f*, beneath the base of the neural arch. The tissue throughout the vertebra is more compact than in *Cetiosaurus* (Mon. cit., Tab. IX, fig. 2).

The neurapophyses (Pl. XII, fig. 1, *n p*) have coalesced with the centrum ; they quickly narrow transversely, above their base, to a thickness of half an inch, more gradually contract in fore-and-aft dimension (Pl. XIII, fig. 2, *n p*) to two inches and a half. Over-arching the neural canal (Pl. XII, fig. 1, *n*), they meet and coalesce about one inch and nine lines above the centrum, whence their compact coalesced mass rises above the crown of the arch, expanding to a height of five inches (posteriorly, Pl. XIII, fig. 1) before giving off the neural spine (ib., *n s*).

At three inches above the base the outer surface of the neurapophysis is excavated by a smooth oval cavity (ib., fig. 2, *p*), 1 inch 9 lines in vertical, 1 inch 6 lines in transverse, diameter, and about 8 lines in depth. To this cavity was adapted the 'head of the rib :' for this part there is no parapophysis, or outstanding process. Below the capitular cavity the outer surface of the neurapophysis is divided from the hinder surface by a low obtuse ridge or angle (ib., ib., *e*) ; a broader ridge (ib., ib., *a*), also low and obtuse, rises along the middle of the outer surface of the neurapophysis, and expands to form the lower margin of the costal pit. In advance of this pit the

neurapophysis extends forward to form the prezygapophysis (ib., and Pl. XII, fig. 1, *z*). The ridge (*e*), rising to the costal pit, forms or extends its hind border and is thence continued, expanding or thickening, into the ridge which forms the diapophysial buttress, *f*. The ridge (Pl. XIII, fig. 3, *a*) does not, in this vertebra, combine with the ridge, *e*, to form the buttress, as in the *Iguanodon* (Mon. cit. Tab. VII, fig. 2), but appears as a shorter independent ridge. A median ridge (Pl. XII, fig. 1, *r*) rises from above the interspace of the prezygapophyses to the neural spine, *n s*. Another median ridge (Pl. XIII, fig. 1, *s*) extends along the back of the neural arch and rises to the interspace of the postzygapophyses, *z'*, *z'*. The chief expanse of the summit of the neural arch in the antero-posterior direction is a zygapophysial one (Pl. XIII, fig. 2, *z*, *z'*); in the transverse direction it is a diapophysial expansion (ib., fig. 1, *d*, *d*).

Each diapophysis is three-sided; the broadest facet is on the upper side, forming with the zygapophyses the neural platform. External to the zygapophyses this surface is 2½ inches from before backward; it is flat. The postinferior surface (Pl. XIII, fig. 1, *f*, *d*) is in that direction concave, most so below the postzygapophyses, *z'*, and growing shallower to the tumid extremity, *d*, of the transverse process. The least fore-and-aft diameter of this surface of the diapophysis is 2 inches 3 lines, that of the antero-inferior surface is 1 inch 5 lines; this is feebly concave across, and is divided lengthwise for part of its extent by the zygapophysial ridge (Pl. XII, fig. 1, *t*).

The free end of the diapophysis is swollen and tuberous; a well-marked facet (Pl. XII, fig. 1, *d*, and Pl. XIII, fig. 2, *d*) cuts the lower part obliquely; it is of a rhomboid shape, nearly flat, and is roughened for the ligamentous attachment of the 'tubercle of the rib;' it measures 2½ inches by 1 inch 9 lines.

The postzygapophyses (Pl. XIII, fig. 1, *z' z'*) are formed by an expansion backward of the neural platform, the pair of processes being indicated by a medial notch; they are more clearly defined by their flat articular surfaces, which are subtriangular in shape, the angles being rounded off; their longest diameter is 2 inches: they look outward and downward.

The prezygapophyses (Pl. XII, fig. 1, *z*, *z*) have been mutilated in the present vertebra, but the extent of their basal origin, 2 inches, may be traced; they are more distinct productions of the neural platform, which abruptly sinks to the level of their medial borders.

The anterior basal ridge (ib., *r*) of the neural spine begins at this lower part of the platform, which it divides into a pair of hollows. The spine rises freely from the broader upper level of the platform. Its base here has a fore-and-aft extent of 3 inches 8 lines. The hind border of the spine is rather sharp; the thickest part of the body of the spine is 9 lines; its free termination was probably, from the analogy of a caudal vertebra subsequently to be described, swollen and tuberous.

A vertebral centrum and a portion of the neural arch, from the same region of the spinal column, repeat the characters, so far as they are shown, of the less fragmentary

vertebra above described and figured. Two views of the centrum, of half the natural size, are given in Plate XII, figs. 2 and 3. The capacity of the neural canal (fig. 2, *n*) is worthy of note; it is rather Mammalian than Saurian, and implies a great development and vigour of the muscular system.

§ 4. Lumbar Vertebræ.—The last lumbar vertebra (Pl. XIX, *l*) appears to be confluent with the first sacral (ib., *s* 1). Its centrum is 3 inches in longitudinal extent; the side is slightly depressed below the base of the neural arch, from which extends a lumbar rib (ib., *l, p l*) 9 inches in length; this is $1\frac{1}{2}$ inches in breadth at three inches distance from its free extremity.

This lumbar rib, and also that of the antecedent lumbar vertebra, are straight and extend transversely to the axis of the vertebral column. The distance in a straight line from the hæmal surface of the lumbar centrum to the end of the last lumbar rib is 1 foot 3 inches.

§ 5. Sacral Vertebræ.—These are five in number (ib., *s* 1—*s* 5), coalesced together, and seemingly with their pleurapophyses. The antero-posterior extent of the five sacral centrums is 1 foot $4\frac{1}{2}$ inches, each centrum averaging $3\frac{1}{2}$ inches in length. After the first they increase in breadth and decrease in the transverse convexity of the hæmal surface, the middle ones showing traces there of a shallow longitudinal hæmal channel with thick low convex borders. The interspace between the heads of the third pair of sacral ribs (ib., *pl.* 3) is 7 inches, between the fifth pair it is 6 inches.

Fractures of the mass of matrix enveloping the pelvis exposed the close cetiosaurian texture of these vertebræ and the shape, in some degree, of the neural canal in a portion of the sacrum. One (fifth) sacral vertebra was thus divided lengthwise through the centrum, neural arch, and spine, and yielded the following dimensions:—Vertical extent 1 foot 5 inches; ib., length of neural spine, 6 inches; antero-posterior diameter of do., 3 inches 6 lines. This spine for a great part of its length was not in contact with the antecedent neural spine. The neural canal partially depresses the upper surface of the centrum of each sacral vertebra, probably in relation to venous sinuses rather than to ganglionic enlargements of the myelon. The vertical diameter of the neural canal where it dips down into the centrum is 2 inches 3 lines; in the ordinary course of the canal, it is 1 inch 2 lines: but, as the fracture affording this view was not exactly along the middle of the vertebra, the canal might gain more depth at that part.

The central part of the sacral centrum shows a rather coarser cancellous texture than the rest, or than is seen in any part of the centrum of an anterior caudal vertebra (Pl. XII, fig. 1).

What appears to be the first sacral rib (Pl. XIX, pl. 1) is slightly dislocated hæmad, and probably, at the same time, bent forward obliquely from above downward and backward in a greater degree than natural, the hæmal end of the articular surface

projecting a couple of inches in advance of the second sacral rib (ib., *pl.* 2). The long or vertical diameter of the head or articular end of this rib-plate is 6 inches; at 3 inches of its outward course it expands to a breadth of $7\frac{1}{2}$ inches by a convex extension of the fore border, which appears to have articulated like a rib-tubercle with the neural arch, and to have been underlapped by part of the ilium (Pl. XIX, *a*). Beyond this point the rib-plate, as it approaches the acetabulum, diminishes in breadth but increases in thickness and seems to develop from its hæmal side a broad, transversely convex ridge or buttress (ib., pl. 1) 5 inches long by $2\frac{1}{2}$ broad at the distal end, which abuts upon the fore and hæmal angle of the acetabulum, *e*. A process of the antacetabular part of the ilium (ib., *a*) is continued inward and hæmad to articulate with the upper border of this first broad, sacral rib; an oblong vacuity, 4 inches by 2 inches, intervenes between this process of the ilium and the acetabulum. The second sacral rib (ib., *pl.* 2) is indicated by the part of the plate posterior to *pl.* 1.

The proximal portion of this seemingly single broad and bifid pleurapophysis is applied to the greater part of the sides of the two anterior sacral centrums (ib., *s* 1, *s* 2), showing it to be the confluence of two pleurapophyses, the part described as the convex side or buttress being the distal articular end of the anterior of these.

On this view the next independent sacral rib would be the third (ib., pl. 3); its proximal end is expanded and applied by a similar, but not so great, obliquity to the side of the third sacral centrum (ib., *s* 3), having a breadth of 3 inches with a thickness of nearly 2 inches, but contracting to a narrow rounded hæmal border, retaining above this part a thickness of 1 inch, then expanding to a breadth of 3 inches to abut upon the hæmal border of the acetabular part of the ilium, filling the interval between the like extremities of the second and fourth sacral ribs. The direction of the third pair is nearly transversely outward. The length of the interspace between the second and third ribs is 6 inches; the fore-and-aft breadth is $3\frac{1}{2}$ inches; it narrows towards the acetabulum, where the distal expansions of these ribbed buttresses come into contact and seemingly coalesce with each other, and similarly narrows to their proximal expansions, thus showing an elliptical shape.

The head of the fourth sacral rib (ib., pl. 4) is applied to the whole side of the corresponding centrum (*s* 4), and is $3\frac{1}{2}$ inches in fore-and-aft diameter; from this the rib contracts to the form of a subvertical thick plate, and then expands to a breadth of 4 inches applied to, and confluent with, the lower border of the acetabulum and a considerable extent of the medial surface of the ilium rising therefrom.

The fifth sacral rib, with the head reduced to $2\frac{1}{2}$ inches in fore-and-aft extent, is applied to the side of the last sacral centrum (*s* 5). This rib, contracting at first like the previous ones, then expands as it extends outwards and slightly backwards, chiefly in the vertical direction, to be applied for an extent of 5 inches to the part of the acetabulum to which the ischium is articulated. A considerable part of the right ischium (ib. 63) is retained, dislocated a few inches from the articular facets (ib., *b*, *c*),

h

and thrust a little mesiad and forward. This bone will be subsequently described showing the proportion of the acetabular cavity contributed by it.

Anterior to the pelvis is a dislocated group of eight hinder trunk-vertebræ, each retaining more or less of its neural arch and processes. On the right side of the pelvis a complete dorsal vertebra is exposed, measuring 1 foot 5 inches in length and 13 inches in breadth, between the diapophyses. The centrum is 3 inches 9 lines in length, 5 inches in breadth, 4½ inches in height, to the base of the neural canal; the hinder outlet of this is pyriform, the apex about 2½ inches in vertical, and 1½ inches in transverse, diameters. From the floor of the neural canal to the base of the spine is 8 inches; the length of the spine is 5 inches.

Beyond this dorsal vertebra is the body of a caudal one, showing a greater degree of concavity of the fore surface of the centrum, which has a breadth of 6 inches.

Behind the sacrum is a dislocated group of four caudal vertebræ, mainly agreeing in character with the subject of Pls. XIV and XV.

§ 6. Caudal Vertebræ.—The vertebra of *Omosaurus* which has been most perfectly wrought out of the matrix is one from the base of the tail; it was in the same block with the sacrum, not far from the hind part of the pelvis.

This anterior caudal vertebra forms the subject of Pls. XIV and XV, of the natural size; and I here subjoin, also, the following admeasurements:

	In.	Lines.
Height or vertical extent of the entire vertebra . .	14	9
Breadth of ditto	14	6
Length at the zygapophyses, giving extreme length of neural arch .	4	2
Centrum, length, lower surface	2	10
,, ,, upper surface	2	5
,, breadth, anterior surface . . .	5	8
,, ,, posterior surface . . .	6	0
,, height, anterior surface . . .	4	5
,, ,, posterior surface . . .	4	6
Neural canal, vertical diameter	2	0
,, transverse diameter, least . . .	1	4
Neural arch, breadth at upper level of centrum . .	5	8
,, ,, across prezygapophyses . .	4	5
,, ,, ,, postzygapophyses . .	2	2
Pleurapophysis, length from base to apex . . .	4	0
,, depth from tubercle to under surface . .	2	3
,, thickness, extreme, at base . . .	1	6
,, ,, at tubercle . . .	0	10
,, ,, below tubercle . . .	0	8

		In.	Lines.
Neural spine, length from fore part of base	. . .	7	1
" " hind part of base	. . .	5	6
" fore-and-aft breadth at mid-length	. .	1	8
" transverse breadth, at mid-length	. .	1	0
" " at tuberous end	. .	2	5

A comparison of such of the above admeasurements as have been recorded of trunk-vertebræ shows that the caudal ones become shortened, at least, at the basal part of the tail. As the length of this appendage would depend upon the number of vertebræ, and especially of those reduced nearly to the centrum, which might again gain in length, it would be premature, on present evidence, to hazard an opinion on this dimension in *Omosaurus armatus.* But the size of the outstanding parts for muscular attachments indicates great power in the tail, which would probably be exercised, as in the largest living Saurians, in delivering deadly strokes on land, as well as in cleaving a rapid course through the watery element.

The centrum is transversely elliptical, with both upper and under surfaces sloping from before downward and backward from the terminal articular planes, these being vertical. Of them the anterior (Pl. XIV, fig. 1, *a*) is flat, with a slight convexity toward the periphery and a shallow transverse groove at the centre; the posterior surface (Pl. XV, fig. 1, *b*) is more decidedly, though but slightly concave; the deepest part here, being along a central transverse groove, with a slight upward bend, like that on the opposite surface. A rugged border for the attachment of a capsular ligament projects from two to five lines beyond the articular tract. This, though smoother than any part of the free surface of the centrum, has evidently, by its inequalities or sculpturing, related to a syndesmosal joint, as in the *Chelone* and *Mammalia,* not to a synovial one as in *Crocodilia.* Between the fore and hind borders of the centrum the lower surface is antero-posteriorly concave (Pl. XV, fig. 2), the concavity narrowing as it approaches the line of confluence of the pleurapophysis (ib., ib., *pl*). This line begins below, half way between the under and upper surfaces of the centrum, and extends upward, approaching obliquely the fore surface (ib., *a*) to overlap and be lost (by anchylosis) in the base of the neurapophysis; a feeble trace of the primitive separation of this element may be discerned at the hinder outlet of the neural canal (ib., fig. 1, *npl*). The pleurapophysial line of confluence is more distinctly traceable; the base of the pleurapophysis, representing the head of the caudal riblet, is broadest below, and there extends nearer the posterior than the anterior surface of the centrum; but, as it rises, it narrows and leaves a larger proportion of the post-lateral surface of the centrum free. The 'tubercle' (*t*) of the rib is a well-marked rough prominence at which the upper border of the rib descends at an open angle with the 'neck' to its obtuse apex. The under border of the riblet is gently concave lengthwise. No diapophysis has been developed, in this vertebra, to afford abutment to the tubercle.

Each neurapophysis at its confluence with the centrum gives a triangular horizontal section (Pl. XIV, fig. 3, *np*), the base of the triangle, 1 inch 5 lines, being anterior, the obtuse apex behind. The inner, shorter side, next the neural canal, is parallel with its fellow and the trunk's axis, the outer side, 2 inches 9 lines in extent, slopes from the broad fore part backward and mesiad to the hind margin of the neural arch.

From the upper and anterior forwardly sloping part of each neurapophysis the prezygapophysis (*z*) is developed; it is short, thick, obtuse, with a flat articular surface, looking upward, inward, and slightly forward; subcircular, an inch in diameter. From the narrower hind part of the neural arch the common base of the pair of postzygapophyses (*z′*, *z′*) rises, expanding to form their articular surfaces, which look in directions opposite to those in front. The hind surface of the common base of these articular expansions has a wide and deep vertical channel.[1]

The neural spine (*ns*) is subquadrate at its base, with the lateral angles broadly rounded off (Pl. XV, fig. 2, *ns*). The line of attachment of the base of the spine rises from before backward (ib., fig. 3). A median anterior ridge (Pl. XIV, fig. 1, *x*) strengthens the lower half of that surface, as a similar but thicker ridge (Pl. XV, figs. 1 and 3, *s*) does the posterior corresponding tract. Where these ridges cease the spine begins to expand into its rough obtuse summit, chiefly transversely, so as to give it an elliptical contour extended in that direction (Pl. XIV, fig. 2).

The foremost of the caudal vertebræ remains in the block of matrix with the sacrum. The present I take to be the second of the series. There is no trace of hypapophysis for a hæmal arch in either of these caudals (the under surface of the centrum of the second is figured in Pl. XIV, fig. 4).

In *Scelidosaurus* the first or foremost caudal alone is devoid of hæmal arch; in the second caudal the lower part of the hind border is touched by the smaller anterior facet on the base of the hæmapophysis (' Pal. Monogr.,' vol. for 1860, p. 8, Tab. VII, figs. 1 and 2, *c* 2).

In the few succeeding caudal vertebræ, with diminution of general size, the vertical extent and the length of the pleurapophyses decrease in a greater ratio. A larger proportion of the side of the centrum is left free below the rib's confluence therewith; and this free surface of the centrum shows, as in the specimen selected for Pl. XVI, an upper (*c*) and a lower (*c′*) depression. The transverse extent of the centrum decreases without corresponding loss of vertical extent. The hind surface of the centrum (ib., fig. 2) becomes more concave, without corresponding increase of convexity of the fore surface. The contour of the hind surface approaches the subhexagonal.

The anterior and posterior ridges of the neural spine subside; the fore ridge is longest retained, but shrinks toward the base of the spine, as at *r*, fig. 1. In the subject of this Plate, as in three other caudals extracted from the matrix, the neural spine has been bent to

[1] It is possible that a similar facet may have been ligamentously attached to the rough surface extended from the lower margin of the terminal surface.

one side, as shown in Pl. XVI, fig. 2. This distortion I conceive to be due to movements of the matrix after the fossil had been inclosed thereby and become petrified therewith. For, being thus supported at every point by the matrix, during the slow and continuous partial pressure, the spine has yielded and bent without breaking. In one instance the sustaining neural arch has suffered partial fracture at the side (ib., fig. 1), toward which the spine has been bent.

A thickening at the outer side of the neurapophysis, feebly indicated in the larger anterior caudals (Pl. XV, fig. 2, *np*), becomes more prominent near the base of the prezygapophysis, as at *np*, figs. 1 and 2, Pl. XVI, in the succeeding smaller vertebræ, in which the hypapophyses are more distinctly marked.

These articular protuberances (ib., figs. 1—3, *hy*) form a pair at the hind border of the inferior surface of the centrum ; the articular tracts at the fore border of that surface are barely defined, or may be indicated by an extension backward of the rough marginal syndesmosal tract.

The caudal vertebra in Pl. XVI is figured a little more than half the natural size. The answerable caudals in the great Monitor Lizard (*Varanus niloticus*) are given, of the natural size, in figs. 4 and 5.

The hæmal arch in the caudal vertebra, with a centrum $5\frac{1}{2}$ inches in vertical extent, has the same length. The hæmapophyses (ib., fig. 2, *h*) are $2\frac{2}{3}$rd inches in length before coalescing to form the spine (ib. ib., *hs*), which is $2\frac{1}{3}$rd inches in length in the subject of the Plate ; it was probably longer when quite entire. But the length of the arch and spine was plainly less in proportion to the vertical extent of the rest of the vertebra than in *Cetiosaurus longus*. The hypapophyses are accordingly relatively smaller, and are limited to a narrower transverse extent of the inferior surface of the centrum (ib., fig. 3, *hy*) than in *Cetiosaurus*, or in the recent *Varanus* (Pl. XVI, fig. 4, *hy*). In *Cetiosaurus brevis* (Pal. vol. for 1857, T. X) the hypapophysial facets (*h, h*) are broader and wider apart than in *Cetiosaurus longus*.

In *Iguanodon* the reverse conditions prevail. These surfaces have become confluent, and present a single bilobed facet to the similarly confluent surfaces on the bases of the right and left hæmapophyses. Both neural and hæmal spines are relatively longer in *Iguanodon* ; and the neural spine springs from a smaller proportion of the hind part of the neural arch at a much greater distance behind the prezygapophyses[1] than in *Omosaurus*. The caudal vertebræ differ less from each other in *Omosaurus* and *Cetiosaurus* than they do in either of these genera as compared with *Iguanodon*.

As in the case of *Cetiosaurus longus* and other Dinosaurian subjects of previous Monographs, I have selected the best preserved specimen of an average-sized vertebra for the subject of figures of the natural size. As the number of these monstrous dragons increases, the judgment of the Council of the Palæontographical Society in voting the cost

[1] Pal. Monogr. for 1854, tt. viii and ix. See also the young or small kind of *Iguanodon*, Mon. cit., t. i, *h*, in which this vertebral character is significantly repeated.

of such 'Plates' will be appreciated, the requisite comparisons being much facilitated, and accurate results ensured, by such life-size figures.

§ 7. HUMERUS.—Of the skull, teeth, or scapular arch of *Omosaurus* I have not as yet received evidence. The humerus and some other bones of the left fore limb (Pl. XVII) have been relieved from the matrix in a more or less complete state.

The *humerus* (ib., figs. 1—5) is remarkable for its breadth, especially at the proximal half, compared with the length. The articular surfaces at both ends have been more or less abraded. That at the proximal end (figs. 1 and 2, *a* and fig. 3, *a*) shows the elongate oval form, with the larger end, *c*, toward the ulnar aspect, narrowing to the beginning of the great radial crest, *b'*, *b'*, as in *Crocodilus*[1] (Pal. vol. for 1858, p. 15; 'Cretaceous Reptiles,' Tab. III, fig. 12), *Varanus*, and most existing Saurians; as in these, also, the head projects somewhat toward the anconal surface (as at *a*, fig. 2); but the prominent part of the shaft continued therefrom is less marked than in *Cetiosaurus longus* (Pal. vol. for 1875, 'Mesozoic Reptilia,' p. 32, fig. 3).

The radial tuberosity (Pl. XVII, figs. 1 and 2, *b*) is not developed distinctly as such, but, as in *Crocodilus* (Monogr. cit., Tab. III, fig. 11, *b*) and *Varanus* (Pl. XVII. fig. 6, *b*), is the beginning of a plate or crest of bone, answering apparently to both the deltoid and pectoral in Mammals, which plate extends considerably radiad, but with less inflection palmad, than in *Crocodilus* or *Varanus*, so that more of its breadth is seen in a direct palmar view, as in fig. 1, than in the Pterodactyle or the above existing Reptiles. It has a certain forward or palmar bend, and subsides a little below the middle of the shaft.

From the proximal beginning, *b*, of this great crest, a broad tuberous rising (ib., fig. 2, *d*) projects anconad, and is continued, narrowing obliquely distad, to terminate or subside at the radial side of the shaft, close to the termination of the crest *b'*. The tuberosity and ridge, *d*, *d'*, might be regarded as 'deltoidean,' as distinct from the 'pectoral' *b*, *b'*, save that its position is anconal instead of palmar. There is a rudiment or indication of this 'anconal ridge' in the humerus of the Crocodile (Monogr. cit., vol. for 1858, Tab. III, fig. 10, *d'*), and a shorter one in *Varanus*. In the latter existing Saurian it gives origin to a muscle answering to the external 'head' or portion of the '*triceps extensor cubite*' in Mammals.

The ulnar tuberosity extends ulnad and distad as a thick tuberous ridge, which terminates more abruptly than the radial crest, at *c*, figs. 1 and 2, about seven inches beyond the proximal end. The broad surface of the humerus between the crests is rather concave across on the palmar surface, somewhat more convex on the anconal surface, which is interrupted by the 'anconal or tricipital tuberosity and ridge.'

[1] The terms of aspect and position are the same as those defined, p. 13 of the above-cited Monograph. Mr. Hulke uses the term 'ventral' to signify the 'anterior' or 'palmar' surface, and 'dorsal' to signify the opposite, 'posterior,' or 'anconal' surface; but he also applies the term 'ulnar' as synonymous with 'posterior' in his description of a humerus referred to the genus *Hylæosaurus*.—'Quart. Journal Geol. Soc.,' 1874.

The shaft at its narrowest part presents in section the form given in fig. 5, Pl. XVII, being almost flat, palmad, and convex anconad transversely. It soon begins to expand into the distal end of the bone. The crest, *e*, simulates the 'supinator' one in Mammals, and is not perforated, as is the answerable disto-radial crest in some existing Saurians. Such perforation is very small in *Varanus* (Pl. XVII, fig. 6, *e'*). There is no indication of this vascular or nervous canal in *Omosaurus*, and the crest is relatively shorter than in *Varanus*. The ulnar expansion, *f*, of the distal end is thick and tuberous.

Sufficient of the radial condyle, *g*, remains to show its Saurian extension palmad, and its convexity in *Omosaurus* (ib., fig. 4); the precise form and extent of the less prominent ulnar condyle or trochlea is not definable.

The texture of the shaft of this humerus, as exposed by the fracture across its middle narrowest part, is compactly dense; there is a small medullary cavity (fig. 5) which seems to have but a short longitudinal extent.

A deep anconal depression (ib., fig. 2, *i*), marks that aspect of the distal expansion in a greater degree than in any Crocodilian, Lacertian, Dinosaurian, or Pterosaurian humerus that, as yet, has come under my notice; it gives to this part of the humerus of *Omosaurus* something of a Mammalian character.

The following are admeasurements of the humerus:

	Ft.	In.	Lines.
Length	2	9	0
Breadth across radial or pectoral crest . .	1	6	0
,, ,, distal end . . .	0	11	0
,, ,, middle of shaft . .	0	5	6
Girth of ,, . . .	1	6	0
Length of base of radial or pectoral crest . .	1	4	0
,, ulnar crest . . .	0	8	0

The figures of this bone on Pl. XVII are reduced to one fourth of the natural size.

Although I should have hesitated to found a genus or generic term on a solitary limb-bone if such distinction had not been supported by the vertebral characters, yet the features were so much more strongly marked in the present than in previously described or figured humeri as to have afforded a better excuse for such taxonomic deduction, which ought to rest, and, as a rule, can only safely do so, on characters afforded by associated parts of the skeleton or teeth.

Mutilated as are the humeri discovered with unquestionable vertebræ of *Cetiosaurus longus* in the Geological Museum of Oxford, justifying the conclusion that they belonged to the same individual, they are unmistakably distinct in character from that bone in *Omosaurus*.

Although the radial or pectoral ridge be broken away in the subjects of figures of the

preceding Monograph,[1] its base has a minor relative extent than in *Omosaurus;* the shaft beyond that ridge expands more gradually into the distal end; the entire length of the bone—4 feet 4 inches in *Cetiosaurus longus*—is greater in proportion to the breadth or thickness of the shaft.

The more slender character of the humerus is still more marked in that bone which chiefly represents Mantell's genus *Pelorosaurus* (Pal. vol. for 1857, Tab. XII), in which the radial or pectoral crest (ib., fig. 2, *d*) subsides above the middle of the shaft, encroaching, as in the *Crocodile, Varanus,* and Pterodactyle, upon the palmar surface of the bone.

The humerus of *Iguanodon* is still less robust in proportion to its length, not to mention its inferior size as compared with associated dorsal vertebræ, than in *Omosaurus.*

In *Hylæosaurus* we find the nearest approach to *Omosaurus* in the proportion of the length of the humerus giving attachment to the great tuberous crests from the radial and ulnar sides of its proximal part. But in the Isle of Wight specimens referred, with doubt, to that Dinosaur, the radial crest is more strongly, and, in reference to its Saurian nature, more typically twisted palmad than in the huger Kimmeridgian genus. It shows a tuberous thickening anconad of its distal end, in the place of the ridge, *d'*, fig. 2, Pl. XVII, in *Omosaurus.*[2]

§ 8. Radius.—This antibrachial bone in *Omosaurus* (Pl. XVII, figs. 7—11) has a subcompressed shaft, expanding moderately and almost equally into the two articular ends, as far as their degree of conservation shows; but it is probable that the more mutilated distal end (fig. 10) when entire would give a somewhat greater breadth than the proximal one or 'head.' This (ib., fig. 9) is of a narrow subelliptic shape. A small part of the concave articular surface, *a*, for the radial condyle of the humerus, is preserved. The anconal surface of the shaft (fig. 7) is feebly divided at its distal two thirds into two facets by a low rising, hardly to be called a ridge, beginning at the middle of that surface at its proximal third and inclining as it descends toward the radial border of the distal end. The concavity of both borders, and especially of the ulnar one, narrows transversely the shaft, but this preserves more equably its ancono-palmar thickness (see the section of the middle of the shaft in fig. 11). The lateral facet (fig. 8, *b*) at the proximal end for articulation with the ulna is more convex than is usual in *Reptilia.*

The surface (ib., fig. 8, *e*) for the insertion of the biceps tendon is well defined. The thenal prominence (ib., figs. 8 and 10, *f*) extending or deepening the cup, *g*, for the scaphoid, is strongly developed, and is thicker than usual, as far as it is preserved. Its outer surface is roughened, as if for the ligamentous attachment of some bone, such surface extending to the angle, *g* (fig. 8), at the broadest part of the distal end of the radius.

[1] On the genus *Cetiosaurus*, p. 31, fig. 3.

[2] Compare Plate XVII, figs. 1 and 2, with similar figures of the humerus of *Hylæosaurus*? given by Mr. Hulke, in the 'Quarterly Journal of Geological Society,' vol. xxx, pl. xxxi (1874).

§ 9. Ulna.—The proximal extension of the articular cup (Pl. XVII, fig. 13, $_a$) upon an anconal or olecranal production marks this bone as strongly as in *Varanus* (fig. 15, *a*) but the excavation (*c*) of the shaft below the proximal end is differently situated. It would seem as if the ulnar or outer border of that depression in *Varanus* (ib., fig. 15) had been moved or extended palmad, in *Omosaurus*, toward the narrower, palmar, surface of the bone; and to such an extent that part of this excavation comes into view from the ulnar side, as at $_c$, fig. 14. This excavation is continued distad for more than half the length of the bone (c, c'). Below this part the shaft assumes a subtriedral form; and its anconal border bends toward that aspect as it approaches the carpus. The articular surface for this segment of the fore limb is wholly destroyed.

§ 10. Manus.—Of the carpal bones have been extracted a left scaphoid, left cuneiform, and left unciform. Of these three large wrist-bones the scaphoid is the smallest, as in *Varanus*, not the largest, as in *Crocodilus*, in which it is connate with the trapezium and trapezoides.

The proximal surface for the radius is more uniformly and less boldly convex; the opposite articular surfaces for the trapezium and lunare is more deeply concave. The outer (ulnar) surface is elongate, narrow, and is the smallest on the bone; it seems barely to have touched the cuneiform, which is here, as in *Varanus*, the largest of the carpals.

The free broader radial surface of the scaphoid is flattened and roughened, and seems to have continued, distad, the corresponding surface of the radius itself, which is on the radial side of the distal end of that antibrachial bone (Pl. XVII, fig. 8, g).

The length (transverse extent) of the scaphoid is 5 inches; the extreme (ancono-palmar) breadth is 3 inches; the extreme proximo-distal extent (on the rough flat surface) is 1 inch 10 lines.

The cuneiform is a massive cuboidal bone, with a proximal surface less concave for the ulna than in *Varanus*, but with as deep an opposite (distal) concavity for the division of the unciforme which supports the fourth digit. There is an approach to the crocodilian character of the bone in the increase of the distal part or surface. The transverse extent of the bone there is 4 inches 9 lines; that of the proximal surface being 4 inches; the ancono-palmar diameter of the bone is 3 inches 9 lines; the proximo-distal diameter is 3 inches 10 lines.

The unciform seems, as in the Crocodile, to have supported both fourth and fifth metacarpals, not to have been divided to afford articulations for these bones on separate portions. Its transverse extent in *Omosaurus* is 6 inches 4 lines; the other dimensions closely correspond with those of the cuneiform carpal.

The digits of a hind foot are longer, as a general rule, than those of a fore foot in existing Saurian Reptiles, and the same proportion has been demonstrated in the fore and

hind feet of some extinct Dinosauria.[1] The proportions, at least, of the metatarsals in *Hylæosaurus* and *Scelidosaurus* support a belief that those of the metacarpals would be as in the homologous bones of *Iguanodon*.

Of the five metapodial bones of *Omosaurus* which have been wrought clear out of the matrix not any show a length as compared with the breadth which exceeds that of the metacarpal of the first digit in the fore-foot of *Iguanodon* (T. III, 1 *m*, Monogr. cit.); and the homologues of the intermediate metacarpals are shorter in proportion to their breadth than in *Iguanodon*.

I conclude, therefore, that the above metapodials of *Omosaurus* are metacarpals, that the digits were less unequal in length, and the whole fore-foot was more massive and elephantine in its proportions, in *Omosaurus* than in *Iguanodon*.

A metacarpal (Pl. XVIII, figs. 3—6) has a flattened proximal surface (ib., fig. 5) of a subtriangular shape, slightly convex near its radial (*r*) and anconal (*a*) periphery, slightly concave toward the palmar border (*p*), which is broken away, the articular surface being continued a short way upon the ulnar (*u*) side of the shaft for junction with the second metacarpal.

The articular surface is pitted with small deepish depressions, as in most great Saurians, where the joint surfaces seem to have been more syndesmosal than synovial. The transverse and ancono-thenal diameters of the proximal surface are equal, each being 3 inches 6 lines; but, had the ulnar border been entire, the transverse diameter would have somewhat exceeded the other.

The short thick shaft of this bone is three-sided; one side extends obliquely from the ancono-ulnar (fig. 3, *au*) angle to the radio-palmar (*rp*) angle, with a transverse convexity; the second, or palmar, side (fig. 4, *p*) is less convex across; the third, or ulnar side, is flat across at the middle part, and somewhat concave near the two expanded ends of the bone. All these surfaces are concave lengthwise, the palmar one least so; but the proximal half of this (fig. 4, *p*, *p'*) has been crushed.

The distal articular expansion (fig. 6), almost flat transversely at its anconal part (*a*), begins to be concave at the middle of the distal surface (*b*), and this deepening to the palmar one (*p*) divides the joint there into a pair of convex trochlear condyles. The radial (*r*, fig. 6) of these, when entire, would have been the most prominent of the two.

The metacarpal (Pl. XVIII, figs. 1 and 2) which supported the fourth digit has a proximal articular surface of a more definite triangular figure (Plate XIV, fig. 5); the anconal border (*a*) being the longest, and the angle between the radial (*r*) and ulnar (*u*) borders being rounded off. The articular surface is continued upon both these sides of the shaft, but further for the articulation with the mid-metacarpal than for that with the fifth.

[1] *Iguanodon*, Pal. Monogr., 'Wealden and Purbeck Reptilia,' vol. for 1856, p. 1, tt. i, ii, iii (hind foot); *Iguanodon*, Pal. Monogr., 'Wealden Reptilia,' vol. for 1871, p. 8, pl. iii (fore foot); *Hylæosaurus*, Pal. Monogr., 'Wealden Dinosauria,' vol. for 1856, p. 18, t. xi (hind foot); *Scelidosaurus*, Pal. Monogr., Liassic Reptilia,' for 1866, p. 17, tt. x, xi (hind foot).

The anconal surface (Pl. XVIII, fig. 1) of the shaft is almost flat and lies more on the plane of that surface of the entire metacarpus than in the marginal metacarpal above described (fig. 3). The radial and ulnar surfaces of fig. 1 converge palmad to the narrow convex palmar surface which forms the rounded angle of the proximal triangular tract (ib., fig. 6, *ur*, *p*). Both radial and ulnar surfaces of the shaft are concave lengthwise and across (ib., fig. 2, *r*). The transverse concavity of the distal articular surface is feebly indicated, and the bifid character of the joint is scarcely marked, though fractured surfaces suggest that a pair of low palmar prominences may have been broken away; but the joint is much less trochlear than in the first metacarpal (ib., fig. 6).

A metacarpal of similar type to the preceding has suffered too great mutilation of both ends to serve for profitable description; it is not a corresponding metacarpal of the right fore-foot, but may be either a second or third, though from the slight superiority of length I should judge it to have been the second metacarpal of the same left fore-foot as the subjects of Pl. XVIII belonged to.

A metacarpal with a subtriedral shaft, and an oblique twist at its basal half through an extension radiad of the radial angle, upon which angle the flat proximal articular surface has extended for the metacarpal on that side, is evidently a fifth metacarpal bone. The distal surface (Pl. XIV, fig. 6) is oblong and almost flat save where it becomes convex on being continued from the basal upon the radial surface; it is feebly concave transversely at its middle half, but this is not continued, deepening, so as to divide the palmar part of the joint into a pair of trochlear condyles. The length of this metacarpal is 5 inches 9 lines; the breadth of the proximal end is 4 inches; of the distal end 3 inches 2 lines; the breadth of the middle of the shaft is 2 inches 3 lines.

The largest of the proximal phalanges extracted gives a length of 5 inches 5 lines; with a breadth of the proximal end of 4 inches, and a breadth of the distal end of 3 inches 7 lines. The breadth of the middle of the shaft is 3 inches; and this seems not to have been more than 1 inch 7 lines in ancono-thenal diameter, but the thenal surface is partially crushed in. The anconal surface is smooth and flat save toward the expanded articular ends. The proximal surface, moderately concave, appears to have been adapted to a distal articular surface of the simple character of the metacarpal last described (Pl. XIV, fig. 6). The distal surface of the phalanx is moderately trochlear, *i. e.*, with a feeble transverse concavity along its middle half; it is strongly convex throughout in the opposite (anconothenal) direction. The size of this proximal phalanx indicates it to have belonged to one of the larger middle digits.

Of the instructive terminal phalanges, the most entire forms the subject of figs. 4 and 5 of Pl. XV. The small proportion of the thin, smooth, punctate, articular surface shows a partial depression at *b*, fig. 4; but the bone is so slightly abraded where that thin smooth crust is wanting as to afford a fairly true figure of its general shape, which is almost flat, with a feeble sinuosity. The anconal border (*a*) is most produced; consequently that surface of the phalanx is longest; but it is little more than half as long as it

is broad. The thenal surface is made concave lengthwise by the thenal production of the terminal lobes of the distal end (Pl. XV, fig. 5). There is no appearance of these being articular. I regard them as the free termination of a last or ungual phalanx, and to show a modification of that end like the terminal phalanx of the second toe in *Iguanodon* (Monogr. cit., Pal. vol. for 1871, Pl. III, *i i*, 3).

Not any of the fragments of phalanges suggested a structure for supporting a terminal claw, such as exists in *Megalosaurus*. The fore-foot of *Omosaurus*, as represented by the bones above described, was a short, broad, massive member, relating chiefly to progressive motion, and suggests the huge species, if not, like *Iguanodon*, phytophagous, to have been a mixed feeder.

§ 11. Ilium.—The mass of matrix with the portion of the skeleton of *Omosaurus* figured in Pl. XIX, reduced to one ninth of the natural size, includes, with the sacrum, both the iliac bones and a large portion of the right ischium. The left ischium and both pubic bones, one of which was almost entire (Pl. XX, figs. 4 and 5), were wrought out of the block in the course of exposing the rest of the pelvis upon which they were lying dislocated.

The length of the ilium is 3 feet 5 inches; that of the antacetabular portion is 1 foot 9 inches; that of the postacetabular portion is 9 inches, but the end of this is broken off on both sides; the breadth of the superacetabular portion is 7 inches; the length of the acetabulum is 1 foot 1 inch; the breadth of ditto is 9 inches; the extent of the unwalled part of the cavity is 7 inches.

Besides the pelvis and the detached vertebræ above noted the right femur and probably the shaft of the fibula were left in the mass in the relative positions exposed in Pl. XIX, in which the pelvis is seen from the hæmal (ventral or lower) aspect.

The ilium (ib., 62—62″) is an oblong, broad, and thick bone, anchylosed by a neuromedial tract, two feet in length, to the expanded ends of the five sacral ribs (ib., *pl.* I—V).

The hæmal surface is divided into an acetabular tract (62), an antacetabular production (62′) of greater antero-posterior extent, and a shorter postacetabular production (62″).

The lateral or external surface, or superacetabular tract, extends neurad and outward to terminate in a thick rugged convex border (*r*), which is continued forward, subsiding as a ridge upon the outer or neural surface of the antacetabular prolongation, (62′); the ridge is lost about nine inches from the fore-end of the antacetabular plate, and gives a triedral form to this part of the ischium. The ridge, continued from *r*, answers to that in the sacrum of the *Iguanodon* noted in Pal. vol. for 1854, ' Wealden Reptilia,' Part II, p. 13.[1] But the proportions of the antacetabular and postacetabular productions are reversed in the Kimmeridgian as compared with the Wealden Dinosaur.[2]

[1] "The outer surface is divided into two facets by a strong longitudinal ridge, for the attachment of some of the powerful muscles of the hind limb."—P. 13.

[2] Compare Pl. III (Monogr. cit.), 62′ and 62″, with Pl. XIX of the present Monograph.

The length of the antacetabular part of the ilium in *Scelidosaurus*[1] more resembles that in *Omosaurus*, but it is narrower and extended more in the axis of the trunk, or is less inclined outward. The corresponding part of the ilium in *Cetiosaurus* resembles in breadth that of *Omosaurus*. In this the acetabular cavity (62) is thirteen inches in longitudinal, nine inches in transverse extent. Its outer and hinder border subsides at *e*, and the cavity is continued upon the superacetabular surface of *r*, the break in the boundary being somewhat analogous to the cleft in the more developed border of the Mammalian acetabulum for the passage of vessels to the intra-acetabular synovial mass. The lower or hæmal part of the cavity is completed by the ischium (ib., 63), which articulates syndesmotically with the surface (*b*, *e*). There is no surface for the articulation of a pubis with the ilium, the *Omosaurus* in this respect corresponding with the *Crocodilia*. In the breadth also of the ilium as compared with the length that bone of *Omosaurus* comes nearer to the Crocodilian than to the Lacertian type.

And, again, in the extent to which the ilium is prolonged in front of the acetabulum the Crocodiles[2] depart less from the Dinosaurs than do the Lizards. In *Lacerta nilotica*, *e.g.*, the ilium is prolonged in front of the acetabulum to an extent equalling only that of the acetabular excavation of the same bone.

§ 12. Ischium.—This bone (Pl. XIX, 63, and Pl. XX figs. 1—3) offers the structural type of that in *Chelonia* and certain *Lacertilia* (*Uromastyx*, *e.g.*, Pl. XX, figs. 8 and 9, 63), in its 'tuberosity' or posterior process (*c*); but, in its slenderness or relation of breadth to length, it exceeds that in any Lacertian or other (to me) known forms of existing Reptile.

Of the iliac articular end of the right ischium but little is exhibited, the bone (63, Pl. XIX) having been pressed forward and behind the part of the acetabulum from which it has been dislocated. The process (*c*) answering to that so marked in *Uromastyx*, in the more perfect left ischium (Pl. XX, fig. 8), comes off nearer the articular end than in the Lizard. The rest of the bone is simply styliform and straight, having no process crossing, as in Birds, the obturator interspace between ischium and pubis. The smooth concavity on the under or hæmal surface of the expanded end, articulating with the ilium, contributes about a fourth part of the cavity for the head of the femur. The end of the process (*c*) is rough, thickened, of an elongate subtriedral form, $2\frac{1}{2}$ inches by 1 inch; the opposite or fore-end of the expansion has a rough syndesmotic surface for the attachment of a similarly roughened end of the pubis. The breadth of the ischium, including these processes, is 13 inches; from this part the bone quickly contracts to a narrow plate. The hind margin of this plate (ib., fig. 1, *e*) is moderately thick and rounded, whence the bone thins off to an edge in front (ib., *f*). The hæmal surface is flat or feebly concave, transversely, and is smooth (Pl. XX, fig. 1). The upper or neural surface is, transversly, rather convex, save where it

[1] Monog. cit., p. 15, pl. vi, fig. 1.

[2] Cuvier, 'Ossemens Fossiles,' 4to, 1824, vol. v, pl. iv, fig. 15, *a*.

extends upon the acetabular part (*a*, *d*), and here it is rather concave. The body of the bone gradually contracts to a breadth of $2\frac{1}{2}$ inches; it then slightly expands to its symphysial end (ib., *g*, and fig. 3), which has a breadth of 4 inches, with a thickness of 2 inches. Restoring a part wanting between the preserved body of the ischium and the symphysial end, to the extent indicated by the dotted lines in Pl. XX, fig. 1, the total length of this pelvic bone in *Omosaurus* would be 2 feet 6 inches.

§ 13. PUBIS.—This bone (Pl. XX, figs. 4—7) presents the type of the pubis in Lacertians (ib., figs. 8 and 9) in the pectineal process (*c*), and the perforation (*d*), but adheres to the Crocodilian type in presenting one articular surface only at the proximal end (*a*) for the ischium, and (seemingly) contributing no share to the acetabular cavity. A Chelonian character is shown in the length of the bone between the head (*a*) and the process (*c*).

The articular end (*a*) has been better preserved than the corresponding one of the left ischium (ib., fig. 1). It presents a narrow, elongate, synchondrosal, roughish facet, 6 inches in length, 1 inch 7 lines in breadth, with a moderate convexity in the long axis (ib., fig. 6). The posthumous abrasion of the articular surface checks an absolute statement as to the precise configuration of this ischio-pubic joint in the recent Omosaur, but the proportion, if any, contributed by the pubis to the acetabulum must have been very small, for no trace of such appears.

The pubis as it recedes from this joint gradually narrows to a breadth of 3 inches 4 lines, then more rapidly expands to form the perforated pectineal plate (*c*). This plate or process becomes, as in Lizards and Tortoises, thickened and tuberous at its free prominent border, which describes a bold convexity before subsiding into the slender continuation of the pubis (*e*, *f*). The margin of *c* continued thereto by the dotted line, in figs. 4 and 5, is a fractured one; and the angle of the border (*e*) to which the dotted line is continued shows also fracture; the extension of bone along that line is inferential. Proximad of such fracture the anterior border of the pubis is entire and sharp, a continuation of that which partly circumscribes the oblique pectineal hole or channel (*d*).

From the pectineal expansion the pubis contracts to a breadth of 2 inches, then expands to its symphysial end (*g*), which, when entire, must have had a breadth of from 5 to 6 inches. The abraded surface (ib., fig. 7) gives a fuller ellipse than that of the ischium (ib., fig. 3), but, as in that bone, indicates a symphysial junction with the opposite pubis. The hind border of the pubis (*f*) is rounded and thicker than the fore border (*e*).

The neural surface (ib., fig. 5) is feebly canaliculate lengthwise in part of its extent, and this character is shown, though still more feebly, in the pubis of *Uromastyx* (fig. 9, 64). But the accentuation of this surface in the broader half of the pubis of *Omosaurus*, as shown in fig. 5, is due to crushing and fracture seemingly in relation to the original prominence of the part of the pectineal process (*c*, fig. 5), which has been pressed to flatness with slight concavity.

I conclude from the length of both ischium and pubis that they diverged from each other, viz., from their outer to their inner or symphysial ends, at an angle nearer that in

Crocodilians than in Lacertians. There is no evidence or indication that these hæmapophyses were disposed otherwise than in the rest of the Reptilian class, meeting, each pair, at the medial line, with a space between ischia and pubes, answering to a common and uninterrupted obturatorial vacuity. This space, in *Dicynodon*, is obliterated by continuous ossification.

The length of the pubis in *Omosaurus* is 3 feet 6 inches, the extreme breadth is 9 inches; the least breadth of the pre-pectineal part (*b*) is 3 inches 6 lines; the extreme thickness of this part is 1 inch 3 lines.

§ 14. Femur.—To the right of the pelvis lies the femur of the same side, with the hinder surface exposed (Pl. XIX, 65). The head (*a*) of the bone is at a distance of 1 foot 8 inches from its socket (*e*) and a little posterior to it. The distal end lies exterior to and a few inches in advance of the right ilium. The terminal articular surfaces of the shaft are, to some extent, worn away, but sufficient remains to show that the chief convexity or head (*a*) projected some inches within the inner longitudinal border of the shaft, the proximal surface sloping slightly distad to the rough convex angle, representing a trochanter (*b*), from which a thick rough ridge is continued, gradually subsiding upon the shaft.

The breadth of the proximal end of the bone is 1 foot 1 inch; at 1 foot distance from that end the shaft is contracted to a breadth of 8 inches, and at its middle part to one of 6 inches. Notwithstanding the posthumous pressure which has shattered this part of the crust of the femur, one may infer that the shaft was naturally subcompressed from before backward.

At three fourths of the distance from the head of the bone the shaft again begins to expand, attaining at the distal end a breadth of 13½ inches. There is a distinct oblong protuberance (*e*) at the inner and back part of the shaft, 1 foot 6 inches beyond the head, corresponding to that more developed prominence which has received the name of 'third trochanter' in *Iguanodon* and *Scelidosaurus*. There is also evidence of a longitudinal ridge (*d*) continued from the back part of the trochanter, about 9 inches down the shaft, inclining toward the middle of the hinder surface.

The popliteal cavity (*e*) is moderately concave, chiefly transversely through the backward production of the outer condyle (*g*). This is of less breadth posteriorly than the inner condyle (*f*) but is more convex as well as more prominent. The outward extension of the femur (*h*) beyond this prominence is somewhat unusual.

§ 15. Tibia.—This bone is represented by its proximal end and three fourths of the shaft (Pl. XXI, figs. 3—6). The shaft is more slender in proportion to the head than in *Hylæo-*[1] or *Scelido-*[2] *saurus*, and yields a full subelliptic section (ib., fig. 6). Part of the

[1] Pal. Monogr., 'Wealden Reptilia,' vol. for 1856 (*Hylæosaurus*), p. 17, pl. vii.

[2] Pal. Monogr., 'Liassic Dinosauria,' vol. for 1861 (*Scelidosaurus*), p. 16, pl. x.

articular surface for the inner femoral condyle may be recognised at *a*, and that for the outer condyle at *b*, fig. 3, Pl. XXI. A procnemial plate (*c*), with a base of 7 inches in extent, projects forward 4 inches beyond the articular part of the head of the bone. As wrought out of the matrix this plate shows a sharper free border than probably was natural; its obtusely rounded summit, *d*, has retained its condition as an epiphysis. The diameter of the head of the tibia in the direction of the procnemial prominence (*a*, *c*, fig. 5) is 11 inches. The preserved longitudinal extent of the tibia is 2 feet. The two diameters of the fracture (*f*, fig. 3) are 4 inches 6 lines and 3 inches 6 lines. The indication of a medullary cavity at the fracture (*f*) are hardly so definite as in fig. 6, and such as it is, the cavity was short; for at the fracture (*e*) the corresponding central portion of the shaft shows an open osseous tissue with wide chondrosal interspaces.

In the obliquely fractured and partly crushed end of the shaft the trace of medullary cavity has disappeared. The osseous tissue of the rest of the shaft is compact. Notwithstanding the degree of crushing, the beginning expansion in the tibio-fibular direction and of contraction or flattening in the rotulo-popliteal direction is unmistakable, and has led me to conclude that the distal, more flattened end of the bone is that which is wanting in the present specimen.

§ 16. Doubtful parts of Hind Limb.—Exterior to the right femur and overlain by it is the shaft or slender part of a bone, 16 inches in length and 3 inches in breadth; it bears the proportion of a fibula to the tibia above described.

Fig. 11.

Metatarsals of Omosaurus ?

No recognisable tarsal, or other bone of the hind-foot, has been detected in the indurated matrix forming the bed of the Omosaur. But Professor Phillips, in his instructive 'Geology of Oxford,' states,[1] "Three metatarsals in the Oxford Museum, apparently of *Megalosaurus*, lying in their original apposition, have been obtained from the Kimmeridge Clay of Swindon and seem to indicate a tridactyle foot (diagram lxviii)." I subjoin a copy of the cut of these bones (Fig. 11), deeming it more probable that they belonged to the genus of Dinosaur now known to have left remains in that formation and locality, than to the *Megalosaurus*, of which no indubitable evidence has yet been obtained from Kimmeridge Clay, either at Swindon or elsewhere. A is an outline of the proximal, B of the distal, ends.

These bones exemplify the 'leptopodal' character of the Dinosaurian foot, due to the reduction of thickness or breadth by suppression of two of the toes, and a consequent departure from the short, thick, or broad 'pachypodal' character of the pentadactyle hind foot of the existing and extinct terrestrial *Chelonia*.

[1] P. 215.

§ 17. Dermal Spine.—One osseous spine (Pl. XXI, figs. 1 and 2; Pl. XXII, figs. 2 and 3) has been successfully wrought out of the matrix; but though a close search was made for other evidences of a dermo-skeleton none have been found.

The spine in question is 1 foot 6½ inches in length, and not more of the tip seems to be wanting than might extend this dimension to 1 foot 7 inches, or, at most, 1 foot 8 inches; the long diameter of its base (Pl. XXII, fig. 2) is 5 inches; the shaft gradually tapers to a point. The spine is rounded and slightly compressed; the narrower diameter is shown in Plate XXI, fig. 1, the greater breadth in ib., fig. 2. The surface, smoothest toward the base, becomes slightly broken by fine longitudinal, *quasi* fibrous, markings; and this sculpturing becomes coarser as the spine contracts. At every part may be seen small orifices, apparently vascular; few in number along the basal two thirds, but more frequent near the point. These indicate a periosteum in relation to the supply of a horny sheath, of which we have here the petrified bony core. The texture of the osseous substance is dense (Pl. XXII, fig. 3).

The base is obliquely truncate, with a boldly sculptured border, broadly and deeply notched as if for strong ligamentous attachments, the whole basal surface being coarsely roughened; it is also channelled, seemingly, by two vessels entering the substance of the spine, one, perhaps, an artery, the other a vein (Pl. XXII, fig. 2). The spine is traversed by a central medullary or chondrosal canal, in diameter one third that of the smaller diameter of the spine (ib., fig. 3). The rough imperforate part of the base, like its coarse periphery, suggests adaptation to syndesmotic junction with some other bone. But with what part of the frame?

There is a want of symmetry at the obliquely truncate base, which suggests this spine to have been one of a pair.

In *Scelidosaurus* the dermo-neural spines at the neck and fore-part of the back are similarly 'somewhat unsymmetrical in form,' showing a parial arrangement along that part of the trunk,[1] but they are succeeded by symmetrical dermo-neural spines having a medial position along the rest of the trunk and tail.[2]

The osseous spines, probably dermo-neural, of *Hylæosaurus*, show a length in proportion to the adjacent vertebral centrums somewhat exceeding the present spine of *Omosaurus*; they are, likewise, obliquely truncate at the base, and unsymmetrical in shape, but in a greater degree; and they are much more compressed.[3]

In the Hylæosaurian specimen in the British Museum, which turned the scale in favour of the dermo-neural hypothesis, an irregular angular depression is described and figured at the base; and this repeats, though single, the pair of depressions or canals above noted, and reputed vascular, in the base of the spine of *Omosaurus*. The low, obtuse, thick ridge

[1] Pal. Monogr., 'Scelidosaurus,' vol. for 1860, p. 25.

[2] Ib., p. 22, pl. ix, figs. 1, 3, 5.

[3] Pal. Monogr., 'Wealden Reptilia,' vol. for 1856, pp. 23—26, pl. iv, pl. ix.

girting the base of the spine in *Hylæosaurus* is, however, simple, unnotched; the provision for attachment of the spine, in *Omosaurus*, betokens a greater power of resistance against displacement. The superior strength of the spine, due to its full elliptical shape in transverse section, suggests its application as a weapon to be wielded for attack rather than as one of a merely defensive palisade of spines.

Considering the number of vertebræ—dorsal, sacral, caudal—which have been recovered in more or less completeness from the intractable mass of some tons weight, including the rest of the above described recovered parts of the skeleton of the Omosaur, it might reasonably be expected that, had the trunk and tail been defended by dermal spines, as in *Scelidosaurus* and *Hylæosaurus*, especially by spines similar in number and arrangement to the dermal ridged scutes in the more Crocodilian Dinosaur of the Lias, more evidences of such appendages to the trunk-skeleton should have been found in the grave of the great Kimmeridgian dragon.

But we are, now, not limited to the head, the trunk, or the tail in quest of positions of armour afforded by dermal bones to extinct members of the Reptilian class.

In the great Mantellian *Iguanodon*, or at least in the male of that species, a pair of spines supported by unsymmetrical conical bony cores were wielded for offensive action by the fore-limbs.[1] The form and proportions of the Iguanodontal carpal spine, especially in its degree of compression, are more like those of the spine in *Omosaurus* than are any of the dorsal spines in *Hylæosaurus*. True, the conical spine-core in *Iguanodon* is shorter in proportion to its basal breadth than is the problematical spine in *Omosaurus*.

It is significant of the nature of this one unsymmetrical osseous spine that the bones of one of the fore limbs, the left, and that limb only, should have been preserved, and in a more complete state than any other part or limb of the present remarkable Dinosaurian framework; the spine in question lay not far from the radius and carpus.

Two spines of similar form to that of *Omosaurus*, but of larger size, were discovered near each other in a pit of Kimmeridge clay at Wootton Bassett, Wiltshire, and formed part of the well-known collection of William Cunnington, Esq., F.G.S., now in the British Museum. Whatever contiguous bones may have been dug out of the same part of the pit were not preserved. These two spines form a pair, and resemble each other as much as would the right and left radius, or the right and left ulna, of the same Dinosaur. They differ from the (carpal?) spines of *Omosaurus* in having a sharp edge, which in a transverse section, like that of fig. 3, Pl. XXII, would terminate one end of the long diameter of the ellipse. The lethal power of the weapon was augmented by this character of the sword added to that of the pike. The degree of obliquity, the coarse marginal notching, and vascular perforations of the base, are as in *Omosaurus*; but the expansion is greater, yielding dimensions of 8 inches and 6½ inches in long and short diameters; there is a slight submedial ridge dividing the basal articular surface into two

[1] Pal. Monogr., 'Iguanodon,' vol. for 1871, pl. ii, fig. 1, *m*, *z*.

shallow channels. The long diameter of the shaft, four inches beyond the least produced part of the base, is $3\frac{1}{2}$ inches, being nearly the same as in *Omosaurus.* The edge of the spine is along the same line as the most produced part of the base. The shaft has a central cavity, as in *Omosaurus.* Should these prove to be a pair of carpal spines they indicate a species of Dinosaur distinct from *Omosaurus armatus.*

§ 18. Life and Affinities of Dinosauria as elucidated by the known character of Omosaurus.—In the 'Isis von Oken,' Band xxiii, Heft v, 1830, 4to, p. 518, Hermann von Meyer proposed the following distribution of Fossil Saurians according to the structure of their hind-limbs :—

" *Saurier mit Zehen, welche denen der lebenden am ersten noch entsprechen würden, und zwar*

" *a.* Vierzehige.

" Rhacheosaurus, *H. v. Meyer.*
" Geosaurus, *Cuvier* (?).
" Teleosaurus, *Geoffroy* (?).
" Aeolodon, *H. v. Meyer.*
" Streptospondylus,
" Metriorhynchus,
" Macrospondylus, } *H. v. Meyer* (?).
" Lepidosaurus,
" Mastodonsaurus, *Jaeger* (?).

" *b.* Fünfzehige.

" Protorosaurus, *H. v. Meyer.*

" *Saurier mit flossenartigen Gliedmassen.*

" Ichthyosaurus, *Conybeare.*
" Plesiosaurus, *Conybeare.*
" Mosasaurus, *Conybeare.*
" Phytosaurus, *Jaeger* (?).
" Saurocephalus, *Harlan* (?).

"*Saurier mit Gliedmassen, ähnlich denen der schweren Landsäugethiere.*

"Megalosaurus, *Buckland.*
"Iguanodon, *Mantell.*

"*Saurier mit Flughaut.*

"Pterodactylus, *Cuvier.*"

The artificiality of these limb-characters has been pointed out, and accepted by the adoption, *e.g.*, of the ordinal distinction of the *Ichthyopterygia* from the *Sauropterygia;*[1] also of the *Labyrinthodontia*,[2] as represented by *Mastodonsaurus* and *Phytosaurus*, from the 'Vierzehige' = *Crocodilia*, Ow.,[3] &c. Whether any apology be necessary for the substitution of the latter term for a defined ordinal group including half of the representatives of von Meyer's "(*a*) Vierzehige" I leave to the judgment of unbiassed palæontologists, and proceed to cite the more definite ascription of taxonomical value to the groups above defined proposed by von Meyer, in his useful compilation called 'Palæologica,' 8vo, 1832. In this work the author prefixes to the class *Reptilien* (p. 101), as to that of *Mammalia* (p. 44), his division of such classes into Orders. Those which he adopts for the 'Reptilien' are—

"A. Chelonier.
B. Saurier.
C. Batrachier.
D. Ophidier."

This was the latest step in Palæontological ordinal classification with which I had to contrast the ideas of the Reptilian orders acquired during the researches of which the results were condensed in my 'Reports to the British Association' of 1840 and 1841.

Von Meyer's subdivision of the Saurian order is based, as in his previous sketch in the 'Isis,' upon the structure of the limbs:

"A. Saurier mit Zehen, ähnlich denen andern lebenden Sauriern und zwar I. Vierzehige. II. Fünfzehige."

[1] "On the Orders of Fossil and Recent Reptilia." From the 'Report of the British Association for the Advancement of Science' for 1859, 8vo, p. 159.

[2] Ib., p. 158.

[3] Ib., p. 164; and "Report on British Fossil Reptiles," op. cit. for 1841, 8vo, p. 63.

"B. Saurier mit Gliedmassen ähnlich denen der schweren Landsaügethiere. 1. Megalosaurus, *Buckland.* 2. Iguanodon, *Mantell.*"

"C. Saurier mit flossartigen Gliedmassen. 1. Ichthyosaurus, *König.* 2. Plesiosaurus, *Conybeare.* 3. Mosasaurus, *Conybeare.* *Streptospondylus,* H. v. M."

"D. Saurier mit Flughaut. Pterodactylus, *Cuvier*" (Op. cit., p. 201).

In the characters of his subordinate group B, Von Meyer (Ib., p. 210) condenses the descriptions and accepts the determinations, clavicle included, of Buckland and Mantell. There is no sign of his having examined any of the fossils on which these descriptions and determinations were based. He is struck with a resemblance of the metapodial bones of *Megalosaurus* in Buckland's plates with those of a hippopotamus; and with the size of one of these bones, "zweimal so breit als im Elephanten" of the *Iguanodon;* and may have deemed their feet, in like manner, to have been tetradactyle or pentadactyle. Such supposed character seems to have suggested to Von Meyer the name *Pachypoda,* which he subsequently applied to them, the proportions of the entire foot which would support such term being to him unknown.

The feet of Dinosaurs are, in fact, characterised by their narrowness or slenderness rather than by their breadth or thickness. The functional toes (hind feet), are, in the typical species of Von Meyer's *Pachypoda* reduced to three,[1] and do not exceed four (*Scelidosaurus,* e. g.) in any veritable member of the order. But had Von Meyer known the structure of the Dinosaurian foot, and it had been such as to have been truly defined by his 'family term,' this term must have given way to the "Pachypoda" proposed and accepted in 1821 for a similar group of *Mollusca;* as the same term, proposed for a family of *Coleoptera,* in 1840, had, in like obedience to taxonomic rules, sunk to the condition of a synonym under the law of priority, even when not affected by inapplicability of the name to its objects.[2]

Every specimen accessible in 1840, of Megalosaur, Iguanodon, Hylæosaur, having been examined and compared by me and the structure of the sacrum elucidated by observations on its development in birds,[3] vertebral characters, with dental ones, were substituted for those of the Family above cited from the 'Isis' and 'Palæologica,' in the definition of the Order *Dinosauria,* quoted by Professor Huxley in his paper on this group.[4] Of this definition the Professor asserts that "every character which is here added to von Meyer's diagnosis and description of his *Pachypoda* has failed to stand the test of critical investigation."[5] This statement is not accompanied with any evidence in its support, but is suggestive that I had dealt unjustly with von Meyer in proposing the name and substi-

[1] *E.g. Hylæosaurus* ('Monogr. Wealden *Reptilia,*' Pal. vol. for 1856, p. 18, pl. xi); *Iguanodon* ('Monogr. Wealden *Reptilia,*' Pal. vol. for 1856, p. 1, pl. i).

[2] *Pachypus* was given to a genus of *Coleoptera* in 1821; this, in like manner, reduced the *Pachypus* applied to a genus of mammals in 1839 to a synonym.

[3] 'Report on British Fossil Reptiles,' p. 106, 1841.

[4] 'Quarterly Journal of the Geological Society,' vol. xxvi, p. 32, 1870.

[5] Ib., p. 33.

tuting the alleged inaccurate characters of the reptilian group *Dinosauria.* If I have to offer, in relation to the main end and aim of my labours, any remark which may seem critical, it will be accompanied by its grounds. Thus, in regard to the characters proposed by Professor Huxley for the Order *Dinosauria*—

"1. The dorsal vertebræ have amphicœlous or opisthocœlous centra. They are provided with capitular and tubercular transverse processes, the latter being much the longer" (loc. cit., p. 33).

If by 'amphicœlous' be meant 'biconcave,' as the term 'amphicœlian' has been applied to dorsal vertebræ of the *Ichthyosaurus,* no such vertebræ exist in the dorsal region of *Dinosauria.* The term 'amphiplatyan' would more truly express the configuration of the terminal articular surfaces of the centrum in such dorsal vertebræ as are figured in Pls. XII and XIII of the present 'Monograph,' and in corresponding vertebræ of *Iguanodon Megalosaurus, Cetiosaurus, Hylæosaurus, Scelidosaurus, Bothriospondylus,* figured in previous Monographs on British Fossil Dinosaurs. Not that the flatness of both ends of the centrum is absolute, but the deviation is slight and usually, when in the direction of concavity, confined to the hinder surface. Neither must it be supposed that the dorsal series may be 'amphicœlous' in one Dinosaur, or 'opisthocœlous' in another.

The centrum in some Dinosaurs, *Tapinocephalus,* e. g., shows at the middle of its flat articular surface a foramen one sixth the diameter of such surface. It is the base of a small conical cavity, the apex of which meets that of the cone of the opposite side,—a beaded remnant of the notochord appearing to have traversed the vertebral column. In other species examined by me certain cervical vertebræ and a few consecutive dorsal vertebræ are 'opisthocœlian,' *i. e.* have the 'ball' in front; and the convexity, in certain of these, does not wholly subside until the lumbar region is reached. But whence did Professor Huxley derive his knowledge of the 'opisthocœlous' character in 'pachypodal Saurians'? If from the original definition of the Dinosaurian group,[1] that character, as there limited, seems to have stood the test of time.

The discoverers of the *Iguanodon* and *Megalosaurus* believed the ball to be behind, and von Meyer accepted this view of the conformity of the Dinosaurian with the Crocodilian dorsal centrums. In fact, the way to distinguish the fore from the hind end of a fossil saurian vertebra seems not to have been known to their describers until the test was defined in 1841. This knowledge, howsoever acquired by the writer of the "Character 1," here discussed, is applied by him in error to *Dinosauria:* in them the ball subsides at the beginning of the dorsal series.[2] I would further remark, that, as there are many modifications and characteristics of the so-called 'capitular transverse processes' and 'tubercular transverse processes,' in the varied series, including Dinosaurian, of vertebral

[1] 'Report on Brit. Foss. Reptiles,' p. 91: "Remarks on Mantell's 'Fourth System' of Vertebræ from the Wealden."

[2] Ib., ib.

structures, the advantage of single substantive terms is exemplified by the convenience and helpfulness to precise description which such terms afford, adjectively, in predicating of 'parapophysial' and 'diapophysial' modifications.

And if by 'capitular portion of the transverse process' Professor Huxley may mean 'parapophysis,' and by 'tubercular portion of the transverse process' 'diapophysis,'[1] I have then to object that the 'dorsal vertebræ' of *Omosaurus* do not all possess the two kinds of processes. In the subjects of Pls. XIII and XIV the head of the rib is received by a pit, not articulated to a 'capitular process.' The dorsal vertebræ, of which the ribs have not 'distinct capitula and tubercula,' have no 'capitular portions, or transverse processes,' *i. e.*, no parapophyses.

In reference to Professor Huxley's "Character No. 2," I submit that a Saurian with sacral vertebræ reduced to two in number is not a Dinosaurian.

"3. The chevron bones are attached intervertebrally and their rami are united at their vertebral ends by a bar of bone."[2] This is a character of *Iguanodon*[3] and of *Scelidosaurus*,[4] but not of *Cetiosaurus*[5] nor of *Omosaurus*,[6] "Char. 3" is one of a genus, not of the Order *Dinosauria*.

"5. The skull is modelled upon the Lacertian, not on the Crocodilian type." For the instances in which the Dinosaurian skull departs from the Lacertian, and approximates to the Crocodilian type, I refer to the Monograph on *Scelidosaurus*,[7] and to that on *Iguanodon*.[8] These instances confirm and add to the combination of Crocodilian with Lacertian characters, propounded, in 1841, as exemplifying the more generalised Saurian type of the extinct order *Dinosauria*.

"6. The teeth are not anchylosed to the jaws, and may be lodged in distinct sockets." The modifications of the dental system in *Dinosauria* concur with those of the skull and jaws themselves in exemplifying the mixed or more generalised character of the group.[9]

"7. There is no clavicle." This is probable from the crocodilian affinities shown in the skull and vertebræ; and the character founded on the bone, so called, in my diagnosis of *Dinosauria*, must be suppressed: but I have not yet seen a specimen of a *Dinosaur* in which the scapular arch was shown in its natural condition and integrity.

Before continuing my remarks on some of the Professor's remaining twelve characters of *Dinosauria*, I would observe, in reference to comments upon the step taken of substituting

[1] 'Quarterly Journal of the Geological Society,' vol. xxxi, p. 426.

[2] Ibid., vol. xxvi, p. 33.

[3] Monogr. 'Wealden Reptilia,' part ii, Pal. vol. for 1854, p. 15, t. viii. (*Iguanodon Mantelli*) ib. ib., t. i, *Iguanodon Foxii* (if this be not an immature specimen).

[4] Monogr. 'Fossil Dinosaur of the Lias,' Pal. vol. for 1860, p. 8, t. vii.

[5] Phillips, 'Geol. of Oxford,' p. 259, fig. 2, 8vo, 1871.

[6] *Ante*, p. 55, pl. xvi.

[7] Pal. vol. for 1859, pp. 7—14, pls. iv, v, vi.

[8] Pal. vol. for 1873, 'Iguanodon,' pp. 4—12, pl. i, fig. 9; pl. ii, figs. 1—15.

[9] 'Odontography,' pp. 246—254, 269—272, pls. 62A, 70, 70A, 1840.

that name of the Order for one of a Family which, for reasons above given, could not have stood in Taxonomy, that the further insight into the structure of *Mammalia* tersely expressed in the names and characters of the Orders in the 'Règne Animal' was gratefully accepted by all single-minded cultivators of Biology, although some of such orders were the same or nearly the same as those defined and otherwise named in the 'Systema Naturæ.' Cuvier was not deterred from fixing this additional step in the advance of Zoology by the opportunity it might open to an objector for charging him with unfairness or injustice to Linnæus; nor was Linnæus much moved by like remarks to which he was subjected by the critics of that era in reference to his names for groups of plants more or less similarly defined, before him, by John Ray, and others.

To return, however, to my proper task, more especially in reference to the affinities of the *Dinosauria.*

The first clue to the homology of the supposed clavicular bone of the Iguanodon [1] was given by Professor Leidy in the 'Proceedings of the Academy of Natural Sciences of Philadelphia,' December 14th, 1858. In the description there given of the fossil remains of a Reptile, which he calls '*Hadrosaurus*,' from the marl of New Jersey, which marl, from the affinity of this Reptile to the Iguanodon, he surmises may be of the Wealden or Green-sand period, Leidy finds, with the ilium, "a bone which I suspect to be the pubic, but which appears to correspond with that of the Maidstone *Iguanodon*, described as the clavicle" (p. 9). In a subsequent illustrated Monograph,[2] Leidy repeats his homology of the bone in question and notes—"an ilium and a supposed pubic bone, imperfect" (p. 71). Of the latter a figure is given ("Pl. VIII, fig. 13"), and the accomplished Author truly remarks :—"It bears a general resemblance to that indicated by Professor Owen and Dr. Mantell as the clavicle of the Iguanodon; but appears to me rather to resemble the pubic bone of the *Iguana* and *Cyclura* than the clavicle of the same animals." [3]

Professor E. D. Cope, Corr. Sec. Academy of the Nat. Sciences, Philadelphia, communicated to the Academy, in 1867, a paper "On the Extinct Reptiles which approached the Birds," of which an 'Abstract' was given in the 'Proceedings of the Academy' for December of that year. In this 'Abstract' the Professor is reported as stating that "he was satisfied that the so-called clavicles of *Iguanodon* and other *Dinosauria* were pubes, having a position similar to those of Crocodilia." [4] There is no reference, therein, to Professor Leidy, nor to the paper by Professor Huxley "On the Classification of Birds" which was published in the 'Proceedings of the Zoological Society,' 1867, p. 415.[5]

1 'Philos. Trans.,' p. 138, 1841.

2 'Cretaceous Reptiles of the United States,' p. 97, pl. viii, fig. 13: in the 'Smithsonian Contributions to Knowledge,' No. 192, vol. xiv, 4to, 1865.

3 Op. cit., p. 97.

4 'Proceedings of the Academy of Natural Sciences of Philadelphia,' p. 234, 8vo, 1867.

5 See "Note," p. 24, in 'Quarterly Journal of the Geological Society of London,' vol. xxvi (1870).

In the lecture " On the Animals which are most nearly Intermediate between Birds and Reptiles," delivered by Professor Huxley at the Royal Institution of Great Britain, 7th February, 1868, he states:—" I hold it to be certain that these bones — the so-called 'clavicles'[1]—belong to the pelvis and not to the shoulder-girdle, and I think it probable that they are ischia; but I do not deny that they may be pubes."

Thanks to the rapidity by which, through science, sea and land can now be traversed, we get the results of research by our American fellow-labourers within a fortnight, usually, after publication.

I have no doubt of the legitimacy of Professor Huxley's assertion—" I could not possibly have known anything about them when my 'Lecture' was delivered;" but the originality of his views of problematical pelvic bones by no means called for any reflection on postal arrangements between Great Britain and the United States. The impossibility might merely mean an oversight which left the writer ignorant of both Cope's and Leidy's anticipations, as appears to have been the case with regard to von Meyer's paper in the 'Isis' of 1830.

In the "Further Evidence of the Affinity between the Dinosaurian Reptiles and Birds," with confirmatory testimony by Professor Phillips, of Oxford,[2] Professor Huxley adopts the ischial homology of the bone in question, and illustrates it by a diagram, "Fig. 3, *Dinosaur*," p. 27 (tom. cit.), in which the supposed " ischium" is directed from the acetabulum downward and backward, parallel with the pubis, with which it articulates by the process (*c*, figs. 4 and 5, in Plate XX, " *Omosaurus* "), so as to " interrupt the obturator space," and define, as in Birds, an anterior part of that space as an " obturator foramen " (loc. cit.).

To an advocate of the affinity of Dinosaurs to Birds and of the derivation of Birds from Dinosaurs, such determination of the bone in question gave great help, and the consequent diagram has been mainly subservient in gaining suffrages to the idea—I may term it sensational—of the kinship of the Iguanodon with the Cassowary, carried to the inference of a common bipedal mode of progression.

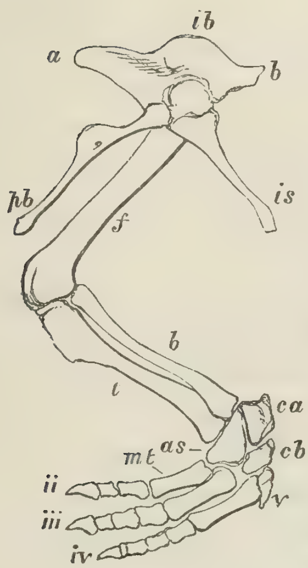
The value of the genus *Omosaurus*, as of every well-determined new Dinosaur, to the Palæontologist desirous, irrespective of foregone conclusions, to lay the basis of lasting views of affinity on fixed homologies, is here great. The bone, Pl. XIX, 63, which completes the acetabulum, shows by the extent and position of its articulation with the ilium, from which it has been but slightly dislocated, that it is the ischium. The recovery of the parial bone to the extent shown in Pl. XX, fig. 1, shows that the shaft gives off no process; also that an extension of the iliac articular end beyond the acetabular surface of the ischium, and behind it, is the sole production, transverse to the axis of the bone, which can be homologised with a non-articular process in the ischia of other Vertebrates.

[1] Erroneously so called in my 'History of British Fossil Reptiles,' part v, p. 265, 4to, 1851.

[2] 'Quarterly Journal,' &c., tom. cit., p. 12.

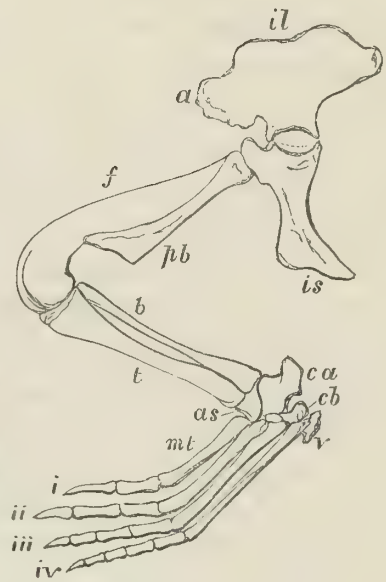
The ischia of *Omosaurus* being thus determined, the homology of the other pair of pelvic bones (Pl. XX, figs. 4 and 5), wrought out of the mass of matrix overlying the hæmal surface of the sacrum and ilia, was plain. They confirm the opinion of Professor

Fig. 12.



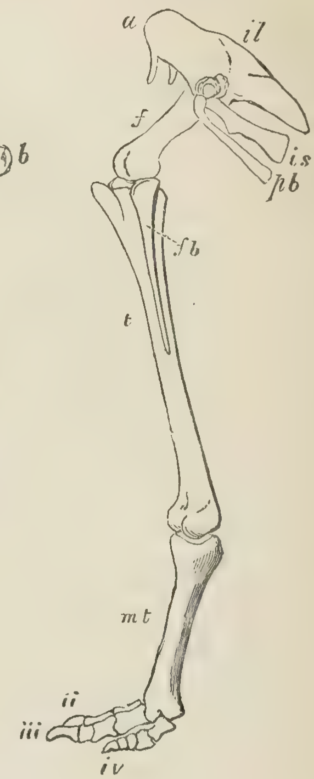
Dinosaur.

Fig. 13.



Crocodile.

Fig. 14.



Dinornis.

Pelvic characters.

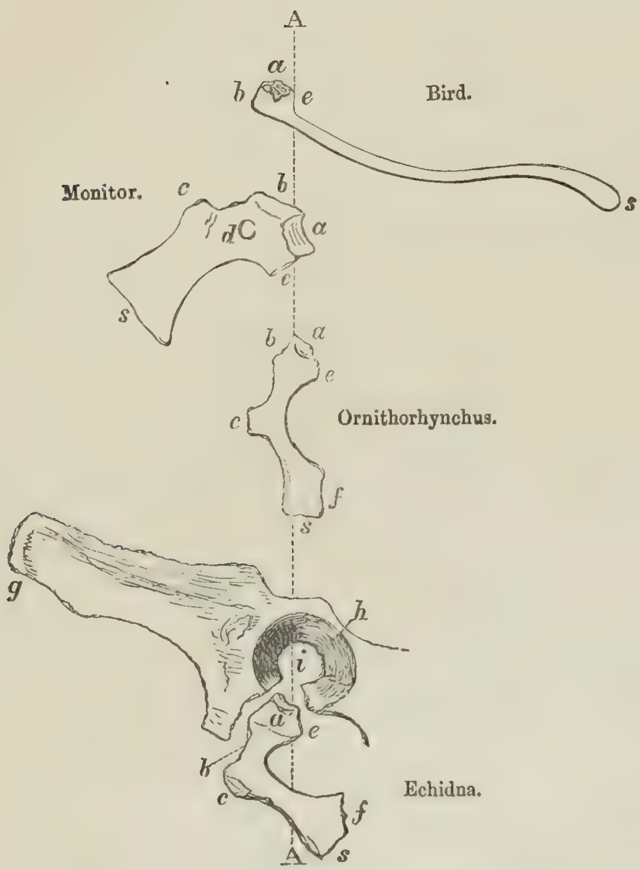
Leidy as to the nature of the bone; and, so far as their dislocated condition indicated their natural direction, it supports the conclusion of Professor Cope that they had " a position similar to those in the *Crocodilia*," *i. e.*, directed forward and downward, as shown by Cuvier, in the 'Ossemens Fossiles,' tome v (1824), Pl. IV, fig. 15, *a*, Pl. V, fig. 6, and as exemplified in my diagram, p. 76, Fig. 13.

So much of the homological ground being thus cleared, we may pass to the question of the affinities it brings into view.

In birds, as a rule, the pubis is a long simple style without process (fig. 15, 'Bird'); the exceptions are chiefly seen in the wingless forms, *Apteryx*, e. g., and the Cassowary, in which latter bird the expanded acetabular end of the pubis projects forward beyond

the joint in a pointed form, about six lines in length. The proximal end of the pubis enters into the formation of the acetabulum in all birds. The distal end terminates, in most birds, freely; in some it is anchylosed to the ischium; in the Ostrich it joins its fellow to form a symphysis pubis:[1] in all it is directed backward and downward.

Fig. 15.



Modifications of pubis. The line A A traverses the corresponding part of the bone.

In the Monotremes the pubis (fig. 15, *Ornithorhynchus*) sends off from its fore part, about one third of its length from the acetabular end, *a*, a low and broad process, *c*, giving attachment to the outer part of the base of the marsupial bone. It joins its fellow at the expanded distal end, *s*, and joins at *f*, the corresponding end of the ischium, thus dividing the obturator interspace into a pair of foramina. As in all mammals the bone is directed downward (hæmad) and a little backward.

[1] For other modifications, which, however, give no help in the present inquiry, see my 'Anatomy of Vertebrates,' vol. ii, pp. 35, 36.

In *Crocodilia* the pubis (fig. 13, *p b*), as in birds, is a simple style slightly expanded distally where it articulates with a cartilaginous abdominal sternum,[1] but it joins not there, directly, either its fellow or the ischium. It contributes no part to the acetabulum, but is attached at its proximal end to an anteriorly produced part of the same end of the ischium (ib. *is*).

In *Chelonia* the pubis is remarkable for its breadth, due to its distal expansion; proximally it contributes to the acetabulum, articulating there with both ilium and ischium, and at or near half way to the distal end, it sends forward a broad and terminally thick pectineal process;[2] it unites distally with its fellow, and in some species also, as in Monotremes, with the ischium, dividing the obturator space. The average proportions and common character of the pubis in *Lacertilia* are given in Cut, fig. 15, *Monitor;* the perforation *d* marks the closer resemblance to the Dinosaurian pubis (fig. 12, *pb*).

Notwithstanding the difference in the proportions of breadth and length, the pubis in *Iguanodon* and *Omosaurus*, in its essential characters, is more like that in the Tortoise than in any bird. But these proportions are among the most variable characters of the bone, and we have not far to seek in the Lacertian order before finding, as in *Uromastyx*, a pubis combining with the pectineal process (Pl. XX, figs. 8 and 9, *b*), as slender a body thence continued as in the *Dinosauria*. Only, in *Omosaurus*, the proximal end of the bone seems not to contribute any share to the acetabular cavity; and, if this should be the case with other Dinosaurs, those extinct reptiles would combine, in their pelvis, as in some other parts of their skeleton, characters now restricted respectively to the Crocodilian and Lacertian groups of the class.

Thus, the ischium, in *Omosaurus*, has no other 'process' save the stunted homologue of the proximal extension supporting the pubis in *Crocodilia.*

In *Chelonia*, as in *Uromastyx*, there is a distinct posterior process (marked *c* in figs 8 and 9, Pl. XX); but in certain Lizards (*Varanus niloticus*, e. g.)[3] it is reduced to a mere rudiment, and in the Chameleon it ceases to exist. Thus, the *Omosaurus* resembles the *Crocodilia* and some *Lacertilia* in the simplicity of its ischium, and markedly departs from the type of birds in respect to this bone.

But it is alleged that the ilium gives evidence of the avian affinity of Dinosaurs which we have now proved to be wanting in the rest of the pelvis. Among the "points of difference between any existing Reptile and any existing Bird," the following is put by Professor Huxley in the foreground.

"1. In the Reptile the ilium is not prolonged in front of the acetabulum." "In the bird the ilium is greatly prolonged in front of the acetabulum."

[1] 'Anat. of Vertebrates,' vol. i, p. 68, fig. 56, *b*.

[2] 'Anat. of Vertebrates,' vol. i, fig. 116, *h*.

[3] Cuvier, 'Ossemens Fossiles,' tom. cit., pl. xvii, fig. 40, *c*.

"Now, in all the *Dinosauria* which I have yet examined, the ilium extends far in front of the acetabulum."[1]

To the first of these averments it needs only an elementary acquaintance with comparative osteology to reply, that in all Crocodilian Reptiles the ilium is prolonged in front of the acetabulum, and to an extent nearly equal to that in which it is produced behind the acetabulum. Reference to the well-known figure in the 'Ossemens Fossiles,' which I here reproduce (woodcut, fig. 13, *il*) exemplifies this fact: Cuvier has been careful to mark with the letter '*a*' the antacetabular part of the ilium which the advocate of the avian affinities and bipedal progression of the *Dinosauria* denies to it and to all other Reptiles, *Dinosauria* excepted.

The true characteristic of the ilium in *Dinosauria* is the distinction of the superacetabular (Pl. XIX, *r*) from the antacetabular (ib., 62′) parts of the bone, with the anterior extension and subsidence, in some species, of the former upon the dorsal surface of the latter.

As to the proportions of the ant- and post-acetabular extensions of the ilium, they vary in known *Dinosauria*: the post-acetabular production (Pl. XIX, 62″) is shorter in *Omosaurus* than in *Scelidosaurus*, and is shorter in *Scelidosaurus* than in *Iguanodon*.

From the importance assigned by Professor Huxley to iliac characters, in the conclusion he advocates, a non-anatomical reader might infer not only that no other Reptiles, but that no other warm-blooded Vertebrates save Birds, had the ilium extended, as in Dinosaurs, far in front of the acetabulum.

And yet an impartial quest of the affinities of these huge terrestrial *Reptilia* would impel the seeker, having such end solely in view, so to extend his comparisons. In Mammals "the ilium is prolonged in front of the acetabulum," which, as in Reptiles, "is either wholly closed by bone or presents a fontanelle."

In the spiny Monostremes (woodcut, fig. 15, *Echidna*) the ilium (*g*) extends far in front of the acetabulum (*h*), and furnishes only an arched roof of that cavity, the inner wall of which (*i*) remains membranous, as in the Bird. The pubis (*a*), after extending hæmad (forward or downward) to the pectineal process (*c*), bends there to be continued backward, as in *Ornithorhynchus*. As a rule all Mammals resemble Birds in a backward extension of more or less of both pubis and ischium, from their iliac articulations.

Thus the character asserted to be peculiar to *Dinosauria* among Reptiles exists in the Crocodilian order of that cold-blooded class; and, amongst warm-blooded Vertebrates, it is common to Mammals with Birds.

In my 'Anatomy of Vertebrates' I remarked, "the transference of the weight of a horizontal trunk upon a single pair of legs necessitates an extensive grasp of the trunk-segments. When the legs require to be pulled far and strongly back, as in diving and cursorial motions, the origins of the requisite muscles are extended far behind the limb's

[1] 'Quarterly Journ. Geol. Soc.,' vol. xxvi, 1870, p. 26.

centre of motion, as in the pelvis of Grebes, Loons, Ostriches, and Emus. When the bird slowly stalks, or hops, or climbs, or uses its legs chiefly in grasping and perching, the pelvis is short and broad, especially behind; its breadth may even exceed its length, as in *Cyclarius guanensis*."[1]

The antacetabular part of the ilium in Birds is usually the longest, but its outer surface is not divided or interrupted by the super-acetabular plate and ridge peculiar to Dinosaurs. To the degree in which the pelvis is produced behind the acetabulum (as in woodcut, Fig. 14, *b*), such production helps to transmit the weight of the body upon the legs in a relative position thereto more favorable to the support of such weight; if the pubis were directed forward instead of backward, it would detract from this relation of the pelvis to bipedal progression. Nevertheless, the balance of the parts so carried in the Bird preponderates forward; the weight of the body with the head and fore-limbs is greatest in advance of the acetabula.

Among the modifications which are associated with the backwardly produced ilia, ischia, and pubes, in relation to the terrestrial progression peculiar to Birds, may first be noted the great extent of the axial trunk-bones welded into one mass where they are grasped by the bones transferring such mass upon the heads of the femora.

In no Birds are the sacral vertebræ so few as in *Dinosauria;* and in those Birds which, from their size and terrestrial habits, are cited to exemplify Dinosaurian affinities, and which best lend themselves to test the question of the locomotion of the great extinct Reptiles, the number of the sacral vertebræ is from 18 to 20. The several species of *Dinornis* had from 17 to 20 sacrals; 12 is the average number in *Natatores*, 12 in *Grallæ* and *Gallinacea*, 11 in *Altrices*. The highest number of sacral vertebræ yet found in *Dinosauria* is 5:[2] in *Dicynodontia* it is 6. The Sloths have 6 (Ai) or 8 (Unau) sacral vertebræ. The extinct Megatherioids, from the great share taken by the massive hind limbs in supporting the body while the fore limbs were engaged in disbranching trees, have a correspondingly closer resemblance to Birds in the structure and proportions of their pelvis than any known extinct Reptiles present. The *Mylodon* had not fewer than 11 anchylosed sacral vertebræ.[3]

In Birds, the trunk, properly so called, as distinguished from the neck, is singularly short; its production in advance of the pelvis is reduced to the utmost, consistently with its visceral relations.

The number of vertebræ between the neck and pelvis, *i.e.* of such as bear pairs of moveable ribs, averages 8, and never exceeds 10; and of these anchylosis commonly fetters the major part.

Between such vertebræ and the skull the 'cervicals' are as exceptional in excess,

[1] 'Anatomy of Vertebrates,' vol. ii, p. 37.

[2] They may in an exceptional instance extend to 6, but demonstrative evidence of this excess has not come to my knowledge.

[3] 'Description of the Skeleton of an Extinct Gigantic Sloth,' &c., p. 64, pls. i, x, 4to, 1842.

numerically; and this concurs with the exceptional reduction of number in the 'dorsals;' both being in special physiological relation to bipedal support and progression.

The numerous cervicals have peculiar joints, governing the sigmoid flexure and oscillating sway of the long and slender neck; whereby, in walking, both neck and head, in Birds, may be brought more directly over the supporting columns of the hind limbs as these change their position. These limbs, moreover, have their specialties in relation to their peculiar work in the vertebrate series.

The femur (Fig. 14 (*Dinornis*), *f*) is relatively short; the tibia (*t*) relatively long; the fibula (*fb*), styliform and short, takes no share in the ankle-joint, but co-operates with the tibia in a special manner to extend and strengthen the articulation of the leg with the thigh. The femoral condyles are concomitantly modified to effect the accessory femoro-fibular joint. Nothing of this exists in Dinosaurian or other Reptiles. Still more special is the modification in Birds by which the leg is united with the foot. No break in the column charged with the sustaining function peculiar thereto in the Bird is allowed beyond the absolute necessities of bending movements of such column when subserving locomotion.

The tarsal segment is suppressed; the metatarsal segment (*mt*) is aggrandised, lengthened out and confluently compacted; the metatarsals of three toes are welded into one bone.

The joint of the leg with this bone is closely and tenaciously trochlear, strictly limiting the movements of the foot to one plane. The long and slender phalanges stretch forward at right angles to the metatarsus, and diverge to form a suitable base for the columns to which has been assigned such an unique task—so peculiar a work—as is performed by the hind limbs on the feathered class.

Certain Dinosaurs wielded carpal spines and some Mammals bore tarsal ones. It would be as germain on that ground to derive *Chauna* or *Palamedea* from *Iguanodon* or *Omosaurus*, as *Platypus* from *Phasianus*.

What are the known structures in *Megalosaurus*, *Iguanodon*, and other *Dinosauria*, which, corresponding with those in Birds, would justify the conclusion or suspicion that the ischium and pubis, besides being long and slender, as they are demonstrated to be in *Omosaurus*, were directed from their acetabular ends backward parallel to one another? It is certain that the ischium in *Iguanodon* had not the 'obturator' process characteristic of the same bone in Birds, and as certain that there must be a mistake about the matter when the same is predicated of the pelvic bone, erroneously called ischium, in the immature or small kind of Iguanodon which has been termed '*Hypsilophodon*' in ignorance of the true structure of the mandibular teeth.

That the pelvic bones, truly homologous with ischia, were "united in a median ventral symphysis,"[1] is most probable from the shape and surface of the somewhat

[1] Huxley, 'Quarterly Journal Geol. Soc.,' vol. xxvi.

expanded distal extremities of the unquestionable ischia in *Omosaurus*. But such union does not exist in Birds. If it should be found in all *Dinosauria*, it is one of the majority of characters in which that order differs from the class of Birds and agrees with its own class, viz. the Reptiles.

Of the comparatively few sacral vertebræ in *Dinosauria* the 'costal portions of the transverse processes' (pleurapophyses) abut chiefly against the part of the ilium contributing to the cup to be upborne by the thigh-bone; there are no postacetabular abutments against other parts of the ilia, or against the comparatively broad ischia, as in Birds. In the latter pelvic character we have again to quit the Reptilian class and to indicate the repetition of it in certain bird-like Lissencephalous Mammals.[1]

The augmentation of number of sacral vertebræ beyond that—two—in Crocodiles and Lizards, whose bellies trail upon the ground or are but little raised therefrom by the outsprawling fore and hind limbs in running along, relates in Land-tortoises to a more vertical position of the leg, and to the greater weight which the entire hind limb has to sustain in the progression of those Reptiles.

In Dinosaurs (woodcut, Fig. 12) the thigh (*f*), as well as the leg (*tb*), were probably less obliquely disposed, in quadrupedal locomotion, than in any existing Reptiles, save, perhaps, the Chameleons. The four or five sacrals, interlocked, as in Birds and Tortoises, by alternating centrums and neural arches, have been recognised as physiologically related to correspondingly developed hind-limbs and a concomitant carriage of their huge elongate trunk, in a way approaching to that in the large gravigrade Mammals.[2]

It is requisite, in the present test, to determine as nearly as may be the relative length of the pre-pelvic part of the trunk to the pelvis in Dinosaurs.

It may be presumed that those who represent the pubic-ischial elements of such pelvis, as being disposed in the avian fashion, intend the inference that, so far, the pelvis of the Dinosaurs related to the same bipedal mode of progression as in Birds, and that the trunk was similarly borne along, prone, upon the single pair of hind-legs.[3]

If, however, our knowledge of the dinosaurian pelvis being rectified, it should be averred that the trunk of the Iguanodon or Megalosaur might be otherwise carried than in Birds, that it was reared upright and so balanced, as in Man, upon a pair of hind, or in that case lower limbs, it may then be necessary to enter upon a series of comparisons between the dinosaurian and human skeletons in connection with such upright mode of progression.

1 'Anat. of Vertebrates,' ii, pp. 397—402, figs. 263, 264, 266—268.

2 'Report on Brit. Foss. Reptiles,' 1841.

3 "Not a ground-crawler, like the alligator, but moving with free steps chiefly, if not solely, on the hind limbs, and claiming a curious analogy, if not some degree of affinity, with the ostrich." Phillips, 'Geology of Oxford,' p. 196. Such an idea, if it ever 'suggested itself' to my mind, was never expressed, and must have been instantly dismissed through considerations akin to those detailed in the text.

At present I shall not spend time in analysing the grounds of such view; but, returning to the avian comparison, I may remark that the number of free vertebræ between the sacrum and skull, in *Iguanodon*, is 24, of which 7 are cervical, 17 dorso-lumbar; in *Megalosaurus* present evidence supports an estimate of 23 such free vertebræ allowing 7 to the neck; in the parts of the skeleton of the same individual *Hylæosaurus*, in the British Museum, 10 vertebræ in natural succession include the hinder cervicals and succeeding dorsals, but the more or less complete vertebræ scattered in the same mass of matrix support an estimate of the vertebral formula not less in number than in *Iguanodon;* whilst, as such vertebræ are shorter in proportion to their breadth than in either *Iguanodon* or *Megalosaurus*, there may have been more than 24 between the skull and sacrum. In *Scelidosaurus* 16 dorso-lumbar vertebræ are shown in succession in the blocks of lias in which they have been exposed, and 6 at least, if not 7 cervicals, are also evidenced in the same instructive skeleton of one individual Dinosaur.[1]

The proportion of the skeleton of *Cetiosaurus longus* in the Oxford Museum and that of the allied Dinosaur (*Omosaurus armatus*) in the British Museum demonstrate the absence of anchylosis in the dorso-lumbar region of the spine, and of any of the modifications of the hindmost vertebræ which, in Birds, add to the mechanical bracing of the trunk upon the pelvis: they show no lengthened pleurapophyses, having free proximal articulations to anterior sacral vertebræ; but, on the contrary, as in Mammalian quadrupeds, the lumbar ribs are short, coalesced with their vertebra, and project as straight outstanding transverse processes, not opposing the lateral movements of the trunk upon the pelvis, but, with the antecedent vertebræ, negativing the notion of any action of muscles, proceeding from the pelvis and thigh-bones to grasp fast a trunk, and uplift it, together with the fore-limbs, neck, and head, clear of the ground, as during the hypothetical bipedal march and course of the huge dinosaurian Reptiles.

The ascertained conformity of organisation in known *Dinosauria* supports the conclusion that a long, bulky, bendible body stretched forward from the pelvis and hind limbs throughout the order.

In Birds the bony 'vertebral' and 'sternal' ribs of the few vertebræ of their short dorsal region are spliced together by a mechanism of which no trace has hitherto been discovered in the corresponding more lengthened region of the spine of *Dinosauria;* there is a like absence, in these cold-blooded vertebrates, of the anchylosis of centrums, and of ossified tendons or neurapophysial splints—avian structures—which limit, to the essential minimum, any movement between one prepelvic vertebra and another. Every modification of the Bird's skeleton concurs to facilitate the carriage of the prone trunk, as one compacted mass, upon the vertical pair of limbs, and not one of these modifications exists in Reptiles recent or extinct.

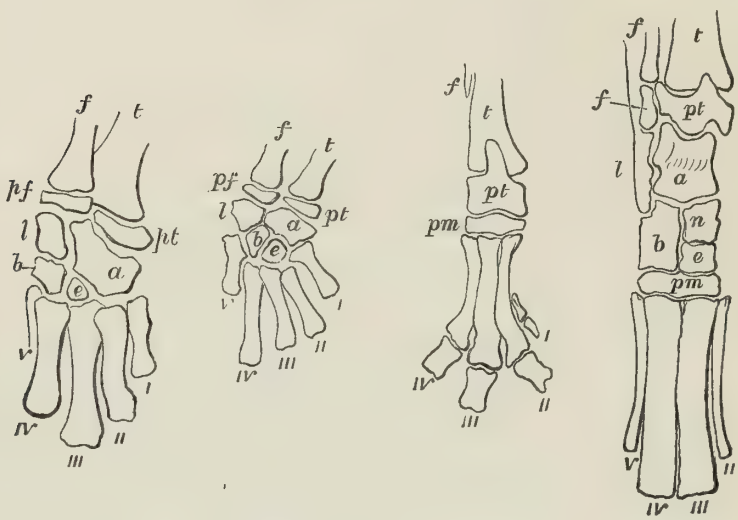
What, then, we next ask, were the arrangements in the neck to diminish the

[1] Palæont. vol. for 1860 (*Scelidosaurus*), p. 11, tab. i—vi.

difficulty which the known structure and proportions of the trunk oppose to the bipedal progression of *Dinosauria?*

Nothing of such exists in the length of the neck, nothing in the number or in the freedom of flexibility in opposite directions of the cervical vertebræ; on the contrary, those vertebræ in *Dinosauria* which are anterior to the bearers of the long and free ribs are few in number, with the little flexibility allowed by their reciprocal joints checked by the disposition of their short and mostly imbricate ribs. The neck of the Dinosaur was short, straight or nearly so, and strengthened by the overlapping pleurapophyses for the

Fig. 16.



Scelidosaurus. Varanus. Young Dinornis. Ruminant.

carriage of a massive head projecting forward almost in a line with the body: never could such head be carried back, by a graceful sigmoid bend of a long neck, so as to be poised above the centre of support afforded exclusively by a hind pair of limbs.

Such head, with its powerful jaws and their dense and weighty dental armature, needed the development and structure of a pair of fore-limbs, to sustain it with the fore part of the trunk, and take the required share in bearing along the bulky dinosaurian quadruped. *Omosaurus* adds a pregnant instance of the requisite anterior pair of supports. What the Dinosaur needed for its mode of terrestrial locomotion the Bird has not; and what the Bird possesses for its mode of terrestrial locomotion the land Reptile is devoid of.

I have alluded to the modifications, extreme and beautiful they are, of the hind limb-bones of the Bird for the functions concentrated therein; the suppression, viz., of the tarsal segment; the simplification, unification, consolidation of the segments above and beneath

it; the tibia alone (woodcut, Fig. 16, *t*) articulating with the metatarsus, ib., *mt*, by a finely fashioned, close-fitting, interlocking joint.

As in all warm-blooded quadrupeds and the majority of cold-blooded ones, recent and extinct, the articular ends of the tibia are ossified independently of the shaft, are in the condition of epiphyses in the young Bird (Fig. 16, *Dinornis*, *p t*), and retain longer that condition in the Reptile (Fig. 16, *Varanus*, *p t*, and *Scelidosaurus*, *p t*). The attachment of the distal epiphysis with the shaft of the tibia (*t*) is made firmer in the biped (*Dinornis*, *p t*) than in the quadruped (Fig. 16, Ruminant, *p t*); and the extent of the attachment is greater, is more irregular or interlocking in the warm-blooded quadruped than in the cold-blooded one; it is still greater in the Bird, in which a process ascends upon the front of the diaphysis, closely fitting to a groove there, and clamping, as it were, the articular epiphysis to the main shaft of the leg bone. The bigger the Bird the greater the share of locomotion allotted to the hind pair of limbs in standing, walking, or running, the longer is the clamping process and the later is the period of the coalescence of the epiphysis with the shaft. The Ostrich among existing *Cursores*, and the Dinornis amongst extinct ones exemplify this relation. In the metatarsus of the Bird the shafts of the ento-, meso-, and ecto-metatarsi are severally ossified from separate centres, but the proximal epiphyses of the three bones are ossified from one centre, and form a single cap of bone where the shafts are still distinct.[1] Such cap (Fig. 16, *Dinornis*, *p m*) may be arbitrarily homologised with one or more bones of the distal tarsal series in Reptiles (Fig. 16, *Scelidosaurus*, *b*, *e*; in *Varanus*, *b*, *e*) and in Mammals (Fig. 16, *Ruminant*, *b*, *n*, *e*). It seems more natural to regard it as answering to the epiphysial cap, covering the ends of the two chief metatarsals, of the Ruminant (ib. ib., *pm*, *iii*, *iv*), and I associate such instances of complex osteogeny of the metatarsus with the high conditions of organisation differentiating the warm-blooded classes, *Aves* and *Mammalia*, from the cold-blood *Reptilia*.

In the Ruminant, as in the Bird, the single epiphysis and multiple diaphyses coalesce into one so-called 'cannon bone.'

In the Dinosauria the hind limbs are not adapted, as in the Birds, for transference of the entire weight of trunk, neck, head, and fore limbs, from the leg upon the foot by due development and modifications of the main leg-bone, the tibia; but the fibula is continued to the ankle-joint, and takes a larger share in its formation than is usual in Mammals. Both leg-bones have their distal epiphyses (Fig. 16, *p f*, *p t*. *Scelidosaurus*, *Varanus*). The tarsal segment is represented, usually by four ossicles:[2] one, *a*, answers, by its connections, to the astragalus, naviculare, and entocuneiform bones of the Mammal; a second, *l*, represents the calcaneum with the lever process slightly if at all developed; there are, also, a cuboid, *b*, and an ectocuneiform, *e*. The metatarsals, whether they be three or four

[1] 'Transactions of the Zoological Society of London,' 4to, vol. iv (1856), p. 149, pl. xlv (*Dinornis elephantopus*, pullus; *Dinornis crassus*, pullus).

[2] Palæont. vol. for 1860, Oolitic Reptilia (*Scelidosaurus*), tab. xi, figs. 2, 3, 4, *Scelidosaurus*, *Varanus*, *Crocodilus*.

in number, never coalesce, but retain their primitive distinctness throughout life. The sole ground taken to bridge over this significant difference in the structure of leg and foot in the Bird and Dinosaur is to affirm that the distal epiphysis, *pt*, of the tibia in the Bird is the homologue of the astragalus in the Mammal and Reptile (Fig. 16, *a*).[1]

"If the whole hind-quarters, from the ilium to the toes, of a half-hatched Chicken could be suddenly enlarged, ossified, and fossilised as they are,"[2] the ilium would be distinguished from that of a Dinosaur by the major number of its sacrovertebral attachments and by their greater extent, by the absence of the ridge continued from the super-acetabular plate upon the antacetabular one; the pelvis would be distinguished by the presence in the ischium of an obturator process wanting in the Dinosaur (Fig. 12, *is*), and by the absence of a pectineal process of the pubis present in the Dinosaur (ib., *pb*), by the parallelism of the ischium and pubis, and by the backward extension of both bones (compare Figs. 12 and 14). The differences grow and multiply as the comparison proceeds; as, *e.g.*, by the non-extension, in the Chick, of the fibula (Fig. 14, *fb*) to the ankle-joint and by the larger and more complex distal epiphysis of its tibia (Fig. 16, *Dinornis*), by the absence of a tarsus, by the backward direction of the innermost or first toe (Fig. 16, *i*), as contrasted with the parallel position of that toe with the second toe in the reptilian foot (Fig. 16, *Scelidosaurus*, *Varanus*). If the entire skeleton of an immature Chick, Ostrich, or Moa were enlarged, whether suddenly or gradually, to the dimensions of that of a Cetiosaur, and were so ossified and fossilised, the characters of the dorsal vertebræ, of the cervical vertebræ, of the skull, and the absence of an anterior pair of limbs with fore-paws organized to be applied to the soil and take their share in the support and progression of a long and bulky trunk and massive head as in the Dinosauria, would be decisive against the reference of such imaginary gigantic Chick to any known representative of the Dinosaurian order of Reptiles. But, to the Biologist who rejects the principle of adaptation of structure to function, the foregoing facts and conclusions will have no significance.

By a modification of the hind-limbs the Bear, and by addition of a longer sacrum to plantigrade feet the Ground-sloth, may assume a crouching bent-kneed attitude and hold the fore-limbs free to grapple with a foe or a tree.

Such is the plasticity of some mammalian structures that, by due training, a Bear, a Dog, or a Monkey may be taught to dance and walk erect for a brief space. It may be doubted whether a cold-blooded, small-brained Reptile could by any training be brought to exemplify the mode of motion conceived in the quotation at p. 92. But that, like the Chlamydosaur with its long-toed, wide-spread, hind feet, the huge Dinosaurs might assume the fighting posture of the Bear, when occasion called them to wield their carpal weapons, is conceivable without commission of physiological or anatomical solecism.

[1] Prof. Huxley, 'Quarterly Journal Geol. Soc.,' vol. xxvi, p. 29.

[2] Ib., loc. cit., p. 30.

The woodcuts, p. 76, Figs. 12, 13, 14,[1] give the pelvis and hind limb of a Moa (*Dinornis*) and of a Crocodile (*Crocodilus*) for comparison with the corresponding parts of a Dinosaur (*Omosaurus*): the position, proportions, and structure of the foot of which are guaranteed by those of *Iguanodon* and *Scelidosaurus*.

In the Crocodile the foot may be applied flat to the ground and the thigh turned out nearly at right angles to the body; but, in some phases of progressive motion, the limb can assume the position delineated: the same may be predicated of the Dinosaurian Reptile. The Bird occasionally rests on the foot, with the metatarsus flat to the ground: but the thigh cannot be turned outward at the angle, which is possible in the Dinosaur and Crocodile. When an accessory trochanter is present in the femur of a Dinosaur (*Iguanodon, Scelidosaurus*), it projects from the inner border of the shaft, not from the outer one, as in the restoration given in Fig. 3, p. 27, 'Quart. Journal Geol. Soc.,' vol. xxvi, 1870.

When the question as to the power of predicating homologies both special and general, as in the case of the bones of the vertebrate skeleton, became finally accepted,[2] the hypothesis of the successive incoming of specific forms or modifications of the vertebrate archetype through the operation of secondary causes was the only one which could adapt itself intelligibly to the facts. In enunciating my conviction that 'nomogeny,' *i. e.* natural laws, or secondary causes, had so operated "in the orderly succession and progression of such organic phenomena," I laid myself open to comments from opposite quarters. On the one hand, the admitted ignorance of the nature and mode of operation of such secondary cause or causes led to the rebuke by a Successor in the chair of the Hunterian Professorship, to wit, that, as to the secondary origin of species, my 'trumpet gave an uncertain sound.' On the other hand, an able, theological critic blew the following note of alarm:—"It is not German naturalists alone who are contributing to diffuse scientific Pantheism. We have in England an anatomist, Richard Owen. To call him an atheist because of his scientific conclusions would be an impertinence; nevertheless, in a lecture on 'The Nature of Limbs' which was delivered at the Royal Institution of Great Britain in February last, and has since been published, he brings all his scientific knowledge and demonstrative skill in support of what is called the Theory of Development, and which has become popularly known by its introduction into the book called the '*Vestiges of Creation*.' This theory of development, as our

[1] The letters have the same signification throughout; *il*, ilium; *a*, antacetabular plate; *b*, postacetabular plate; *ib* (in the Dinosaur) marks the superacetabular plate; *is*, ischium; *pb*, pubis; *f*, femur (of this only the lower part of the bone is given, so as not to conceal parts of the pelvis important in the comparison); *t*, tibia; *b* or *fb*, fibula; *as*, astragalus; *ca*, calaneum; *cb*, cuboides; *i*, inner or first toe; *ii*, second toe; *iii*, third toe; *iv*, fourth toe; *v*, rudiment of fifth toe.

[2] 'Hunterian Lectures,' Royal College of Surgeons, 1844; 'Reports of the British Association for the Advancement of Science,' "On the Archetype and Homologies of the Vertebrate Skeleton," 8vo, 1846; and 'Discourse on the Nature of Limbs,' 8vo, 1849.

readers may know, assumes that God did not interpose to create one class of creatures after another as the consequence of each geological revolution; but that, through the long course of ages, one class of creatures was *developed* from another. Now, Richard Owen undertakes to demonstrate *scientifically* (and his demonstration is very rigorous) that the arms and legs of the human race are the later and higher developments of the ruder wings and fins of the vertebrated animals—that is, those which have a true back-bone; and he shows in the splint bones of the foot of a horse, bones analogous to those of the fingers of the human hand. Therefore he concludes that God has not peopled the globe by successive creations, but by the operation of general laws."[1]

The sole ground for Professor Flower's depreciatory remark is my acknowledgment of being "as yet ignorant"[2] of the nature or way of operation of such general or secondary laws; and I regret to say that after all that has been advanced since 1849 in the endeavour to elucidate the way in which one species may be transmuted into another, I am still in need of light.

Assuming that the ornithic modification of the vertebrate archetype was one of those under which the 'vertebrate idea' became embodied in the course of progression from "its old Ichthyic vestment,"[3] two questions present themselves:—Out of what antecedent vertebrate modification was the avian one evolved? How, or under what conditions or secondary influences, was such evolution effected?

The hypothesis of the bipedal locomotion of the *Dinosauria*, the advocated homology of their os pubis with the ischium of the bird, and the alleged restriction of the avian antacetabular production of the iliac bone to the *Dinosauria* among Reptiles, have been superadded to the proved fact of a correspondence of structure between the shorter sacrum of the Dinosaurs and the longer sacrum of Birds as grounds for the conclusion that Birds are transmuted Dinosaurs, and that the feathered class made their first step in advance under the low form of *Struthiones* or *Cursores*, incapable, as yet, of flight. The kind and amount of modification required to evolve an Ostrich out of an Iguanodon may be appreciated by the osteological comparisons already submitted in the present monograph. To revert only to the structure of the fore-limb. In losing its power of aiding in the quadrupedal progression, and of grasping or otherwise applying the hand, it has as yet, in the hypothetical first form of Birds, gained no other faculty. At best it may help in the swift course of the ostrich by flapping motions similar to those of better birds during their flight; or the more minute monodactyle hand may just serve to scratch the back of the head, as in the New Zealand Kivi. In their larger extinct relatives, the Moas, it is still doubtful whether more of the framework of a fore-limb existed than the supporting scapular arch, and that of the simplest character.

1 'Little Lectures on Great Topics,' 12mo, 1849.

2 'On the Nature of Limbs,' p. 86.

3 Ibid.

In all these gradations of structure in a limb unavailable for flight or any other mode of locomotion we see no approach in the scapula to the Dinosaurian types of that bone; it retains in all Cursorials the strictly avian sabre-like shape and pointed free extremity, without expansion and truncation there such as obtains in the alleged ancestral *Reptilia*.[1] The coracoid still further departs from any well-determined Dinosaurian type of the bone, and as closely adheres to that of the Birds of flight, save such decrease of breadth and of relative size as accords with its necessity to bear upon the sternum in the mechanical mode of inspiration peculiar to Birds with Pterodactyles.

What could be the conceivable conditions of the life of an Iguanodon or Megalosaur which rendered a fore-limb useless or cumbersome, and concomitantly called for lengthened and strengthened hind-limbs and a more vigorous and exclusive exercise of these in the acts of locomotion? The abettors and acceptors of the exposition of the operation of the secondary mode of origin of species by way of 'natural selection' are amenable to the call for an explanation of such conditions, especially if such mode of origin be hypothetically applied to the kinds of Birds deprived of the power of flight. But such explanation would have to square with the fact that a loss of one pair of limbs had been associated, on the assumption of the Dinosaurian ancestry, with an advance of the mechanical structure of the organs of circulation, and in the extent and perfection of the lungs, together resulting in the higher temperature, with more numerous and minute coloured discs of the blood. For these conditions of the vital organs characterise alike both winged and wingless Birds, and the resultant unvarying warmth of the body is accompanied by a clothing of down and feathers, the most exquisite and complex of all tegumentary coverings, common to the Kivi and Ostrich with the Eagle and Swift.

But there are other hypotheses of the way of operation of secondary genesis of species anterior in date to that of Darwin. The influence, viz., of exercise and of disuse in altering the proportions of parts mooted by Lamarck;[2] the hypothesis of 'degeneration' propounded by Buffon;[3] and the effects of congenital changes in parts of the body, mainly depended upon by the author of 'Vestiges,' in his endeavour to explain the way of operation of the secondary law of the origin of species.

The comparative ease is so refreshing, after the labours of induction and dry description, in supposing a case, that I may be forgiven for indulging in a suggestion of a possibility of the few still extant wingless or flightless birds having originated, not from any lower cold-blooded vertebrate form, but from higher active volant members of their own warm-blooded feathered class. Consideration of extinct kinds, in the restoration of which I have been occupied, has strengthened the supposition.

Here, in yielding to this indulgence, I own to finding more help from the Lamarckian

[1] Compare, for example, the scapula of the Apteryx, 'Transactions of the Zoological Society,' vol. ii, pl. xxx, fig. 2, *g*, and figs. 3 and 4, with Cut, fig. 2, p. 31.

[2] 'Philosophie Zoologique,' 2 vols., tom. i, chaps. iii, vi, vii, 8vo, 1803.

[3] 'Histoire Naturelle,' tom. xiv, p. 311, 4to, 1766.

hypothesis than the Darwinian one, and I am ultimtely lead to propound the *Struthionidæ* as exemplifications of Buffon's belief in the origin of species by way of degeneration; on other grounds than those on which my anonymous Critic, above cited (p. 87), views the Papuan and Boschisman in relation to an antecedent higher, indeed perfect, form of man.

Let us suppose, for example, an island affording abundant subsistence to vegetarian birds, and, happily for them, to be destitute of creatures able or desirous to destroy such birds. If the food was wholly, or chiefly, on the surface the power of traversing such surface would be of as much advantage to the bird as to the herbivorous quadruped. As flight calls for more effort than course; so cursorial progression would be more commonly practised in such a happy island for obtaining the daily food. The advent or proximity of a known element of danger might excite the quicker mode of motion; the bird would then betake itself by a hurried flight to a safer locality. If, however, certain insular birds had never known a foe, the stimulus to the use of the wings would be wanting in species needing only to traverse the ground in quest of food. In the case of New Zealand, for example, the roots of wide-spread ferns, being rich in farinaceous and amylaceous principles, the habit of scratching them out of the ground would lead to full development of the muscles of the leg and foot. So, such daily habitual exercise of legs and feet by unscared Rasorials would lead in successive generations to strange developments of hind-limbs; whilst the disuse of the wings during the pre-Maori æons would lead to their atrophy. The Lamarckian hypothesis has, in fact, this advantage over others of like kidney, that physiology testifies to the relation of growth to exercise, and of waste to disuse, and so far votes in favour of the conditions evoked by Lamarck as *veræ causæ* in transmutation. We recognise in the stunted wings of the Dodo, for example, their close conformity, save in size, and in the prominence of their processes for muscular attachments, to the scapula, coracoid, brachial and antibrachial bones, carpus, metacarpus, &c., of the perfect instrument of flight in truly winged birds, evidences of its affinity; and such conformity of structure is agreeable with the hypothesis of the origin of the Mauritian species of ground-pigeon through descent or degeneration. The differences which the wing-bones of the Dodo present when compared with their homologues in the *Iguanodon* is in the same degree adverse to the hypothesis of its evolution from any such reptile, in the direction of ascent and improvement. The same course of argument applies to the impennate Awk, the Cassowary, Rhea, Ostrich, &c., as to the wingless birds of the Mascarene, Polynesian, or Melanesian Islands.

Confidence in the impartial exercise by Biologists of the logical faculty leads to the conclusion that their science will accept the view of the Dodo as a degenerate Dove rather than as an advanced Dinothere. But whence the dove? Are we then, I will not say driven, but rather guided, to the old belief that the winged bird was "created" in the sense of being miraculously made, at once, out of dust, agreeably with the alternative hypothesis conceived by my critic? Or, is a belief in a Dove's coming to be through the

operation of a secondary law still legitimate and germain to our truth-seeking faculties? Not necessarily relegating an honest inquirer to the bottomless pit of Atheism, if he should happen to ask :—Were there no volant vertebrates of earlier date and lower grade than the "Fowls of the Air"?

Without knowing or pretending to know the way of operation of the secondary cause, the vast increase of knowledge-stores of biological phenomena makes it as impossible to comprehend them intelligibly in any degree, on the assumption of primary or direct creation of species, as it was impossible for Copernicus to understand and explain the vast accession of astronomical facts, on the belief of the subservient relation of sun to earth, of the posteriority of the creation of the luminary to the light-receiver, and of their respective relations of motion, as received in his day. To the objection, how, on his assumption of the diurnal rotation of the earth, loose things remained on its surface, Copernicus could offer no explanation. Neither has the Biologist been able, as yet, to explain how the Ramphorhynchus became transmuted into the Archeopteryx. It is open, of course, for any one to deny such change. What seems to me to be legitimate, in giving an account of the labours that have resulted in a certain accession to the knowledge of extinct forms of cold-blooded, oviparous, air-breathing Vertebrates, is the indication of the respective vicinity of certain groups of such now much reduced class to the warm-blooded oviparous Vertebrate air-breathers which in our times so greatly prevail in life's theatre.

Every bone in the Bird was antecedently present in the framework of the Pterodactyle; the resemblance of that portion directly subservient to flight is closer in the naked one to that in the feathered flyer than it is to the fore-limb of the terrestrial or aquatic Reptile. No Dinosaur has the caudal vertebræ reduced as in Birds; many Pterodactyles manifest that significant resemblance. But some Pterodactyles had long tails and all had toothed jaws. A bird of the oolitic period[1] combined a long tail of many vertebræ with true avian wings, and it may have had teeth in its mandibles. It is certain that a later extinct bird,[2] though of an early tertiary period, far back in time beyond the present reign of birds, had tooth-like processes of the alveolar borders of both upper and lower jaws.

Fact by fact, as they slowly and successively drop in, testify in favour of the coming in of species by 'nomogeny,' and speak as strongly against 'thaumatogeny'[3] or the multiplication of miracle on the alternative hypothesis of the writer of 'Little Lectures on Great Things.' He and his school invoke a cataclysm to extinguish the Palæothere, and an inconceivable operation to convert dust into the Hippothere; yet a slight disproportion of the outer and inner of the three hoofed toes of each foot of these quadrupeds is their main difference. My critic again invokes a cataclysm to extinguish the race of Hippotherian species and again requires the miracle to create the Horse. Yet the loss of the small side-hoofs that dangled behind the main mid-hoof in the Hippothere is the

[1] *Archeopteryx*, 'Philosophical Transactions,' 1863.

[2] *Odontopteryx*, 'Quarterly Journal of the Geological Society,' 1873.

[3] 'Anatomy of Vertebrates,' 8vo, vol. iii, p. 814.

chief organic distinction between *Hippotherium* and *Hippos.* Every bone, every tooth, present in the eocene and miocene predecessors of modern Horses is retained in them, with slight changes of shape and proportion. The second and fourth metacarpals which bore hoofed digits of moderate size in eocene days, bore them of diminutive size in miocene days; and now, when such dangling spurious hoofs are gone, their metacarpal and metatarsal suspensories still remain, hidden beneath the skin, and ending in a point where, of old, was a well-turned joint.

It has become as impossible to square the hypothesis of "the peopling of the globe during the long reign of life thereon, by successive and special creations" with the known vital phenomena, as it was impossible to explain the sum of astronomical facts, accumulated in the fourteenth century by the cumbrous machinery of cycles and epicycles, necessitated under the assumption of the globe as the fixed, central, and largest body of the Universe. Biology seems now to be at the Copernican stage; and if the rejection of the incoming of species by primary creative acts should exercise an influence on the progress of that science akin to that of astronomy after the abandonment of the faith in the earth's fixity, Biologists may confidently look for as rapid a progress through acceptance of Nomogeny.

What, then, may be the meaning of the reduction of bulk in the fore-limbs of certain Dinosaurs? Does that reduction indicate a step in the conversion of such Reptiles into Birds? Do we get an explanation of the small fore-limbs by the picture which Professor Phillips vividly presents to us "of the grand and free march on land chiefly, if not solely, on the hind-limbs?" Or, is the fact of the disproportion of size between the arms and legs in the Megalosaur and Iguanodon susceptible of other than the Oxfordian hypothesis?

As a matter of fact, such disproportion is shown by Crocodilian Reptiles still in existence; whilst extinct Crocodiles of more aquatic habits and marine sphere of life had the fore-limbs as much reduced in size as in any known Dinosaur.[1] Of this *Teleosaurian* character the physiological explanation which has been advanced is, that the course of such Crocodile through water, due to the action of the long, laterally flattened tail, would be facilitated, or less impeded, by such reduction of size of the fore-limbs, those limbs taking no share in the forward dash of the piscivorous reptile in pursuit of its prey, and if of any use in the water, being limited in natatory evolutions to assist in a change of direction; the fore-limbs, in fact, being mainly if not wholly required to help in the progress of the amphibious beast upon dry land, or to scratch out the nest in the sand. Actual observation of a swimming Crocodile testifies to the fore-limbs being then laid flat and motionless upon the sides of the chest. All known Dinosaurs have the Crocodilian swimming organ; the Iguanodon exemplifies the compressed vertically broadened tail in

[1] "Monograph on the Fossil Reptilia of the London Clay," part ii, in the Volume of the Palæontographical Society for 1849, p. 24, t. xi.

an eminent degree. And just as such appendage was essential to the proportion of the active life of these huge cold-blooded amphibians which was spent in the watery element, so such far-produced caudal fin must have been a cumbrous impediment to the way of walking upon dry land pictured in the work giving figures of the caudal vertebræ and other bones of the *Cetiosaurus longus.*

In the ratio in which the fore-limbs approach the hind ones in size may be inferred the proportion of time spent by the huge reptile on land, and the importance of the share taken by these limbs in such quadrupedal mode of progression: when the Dinosaur betook itself to water its fore-limbs would be, most probably, disposed as in the Crocodiles.

If, then, the hypothesis that the reduced fore-limbs of *Dinosauria* receive the most intelligible, and therefore acceptable, explanation, admitting the principle of adaptation of structures to functions, agreeably with the analogy of such living animals as are most nearly allied to them in organization; the notion that Birds, under their wingless conditions, were derived from Dinosaurs may be safely left to the judgment of whomsoever may be disposed to bring unprepossessed and impartial judgment to the consideration of the hypothesis.

PLATE III.

Bothriospondylus suffossus.

Fig.

1. Hæmal or under view of centrum of sacral vertebra.
2. Neural or upper view of the same.
3. Hind view of the same.
4. Right side view of the same.

All the figures are of the natural size.

From the Kimmeridge Clay at Swindon, Wilts. In the British Museum.

C. L. Griesbach del & lith. M & N Hanhart imp

BOTHRIOSPONDYLUS SUFFOSSUS

PLATE IV.

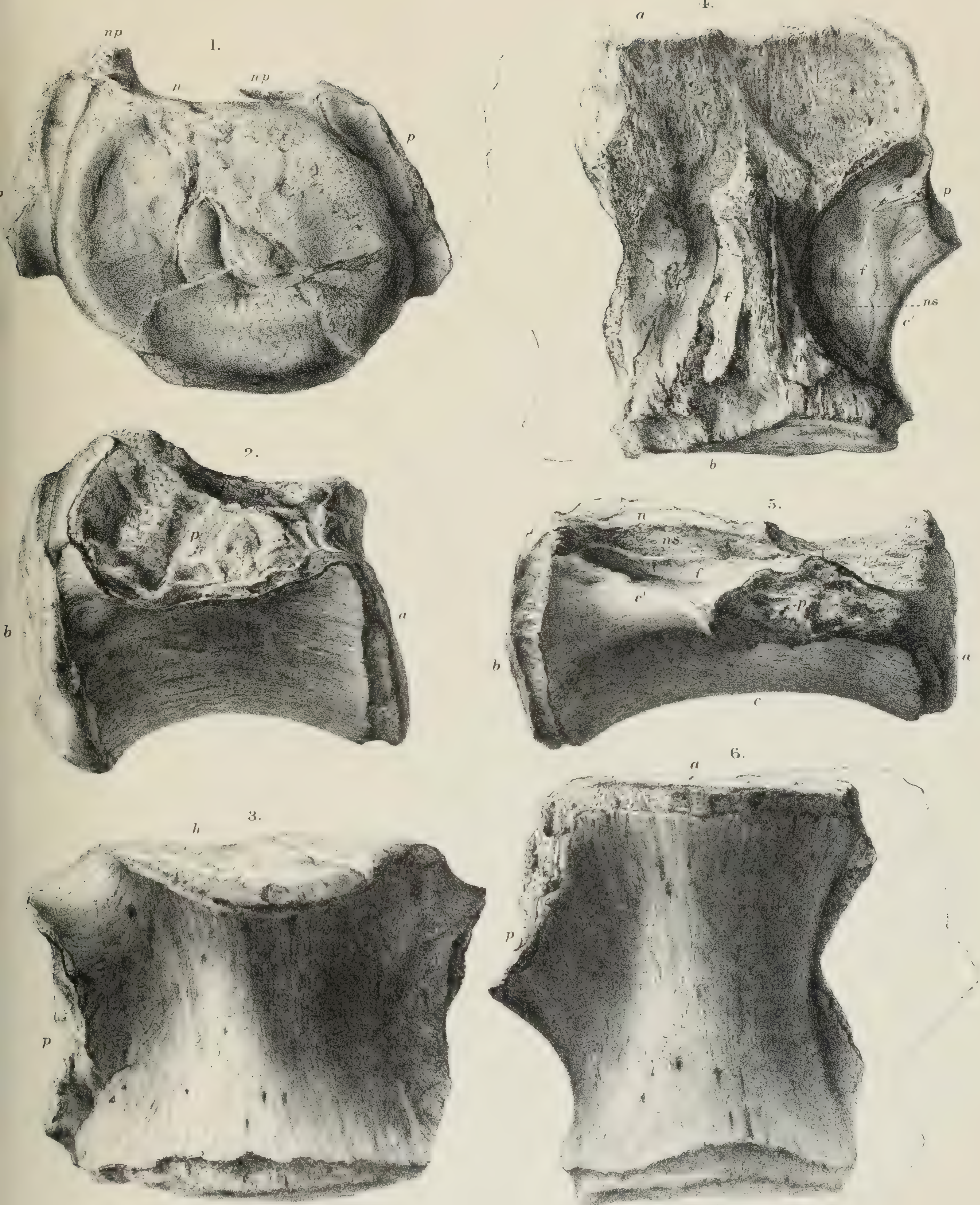
Bothriospondylus suffossus.

Fig.

1. Hind view of terminal centrum of sacral vertebra.
2. Right side view of the same.
3. Hæmal view of the same.
4. Neural view of mutilated centrum of sacral vertebra, restored in outline.
5. Right side view of the same.
6. Hæmal view of the same, restored in outline.

All the figures are of the natural size.

From the Kimmeridge Clay at Swindon, Wilts. In the British Museum.



C. L. Griesbach.

Mintern Bros imp.

BOTHRIOSPONDYLUS SUFFOSSUS.

PLATE V.

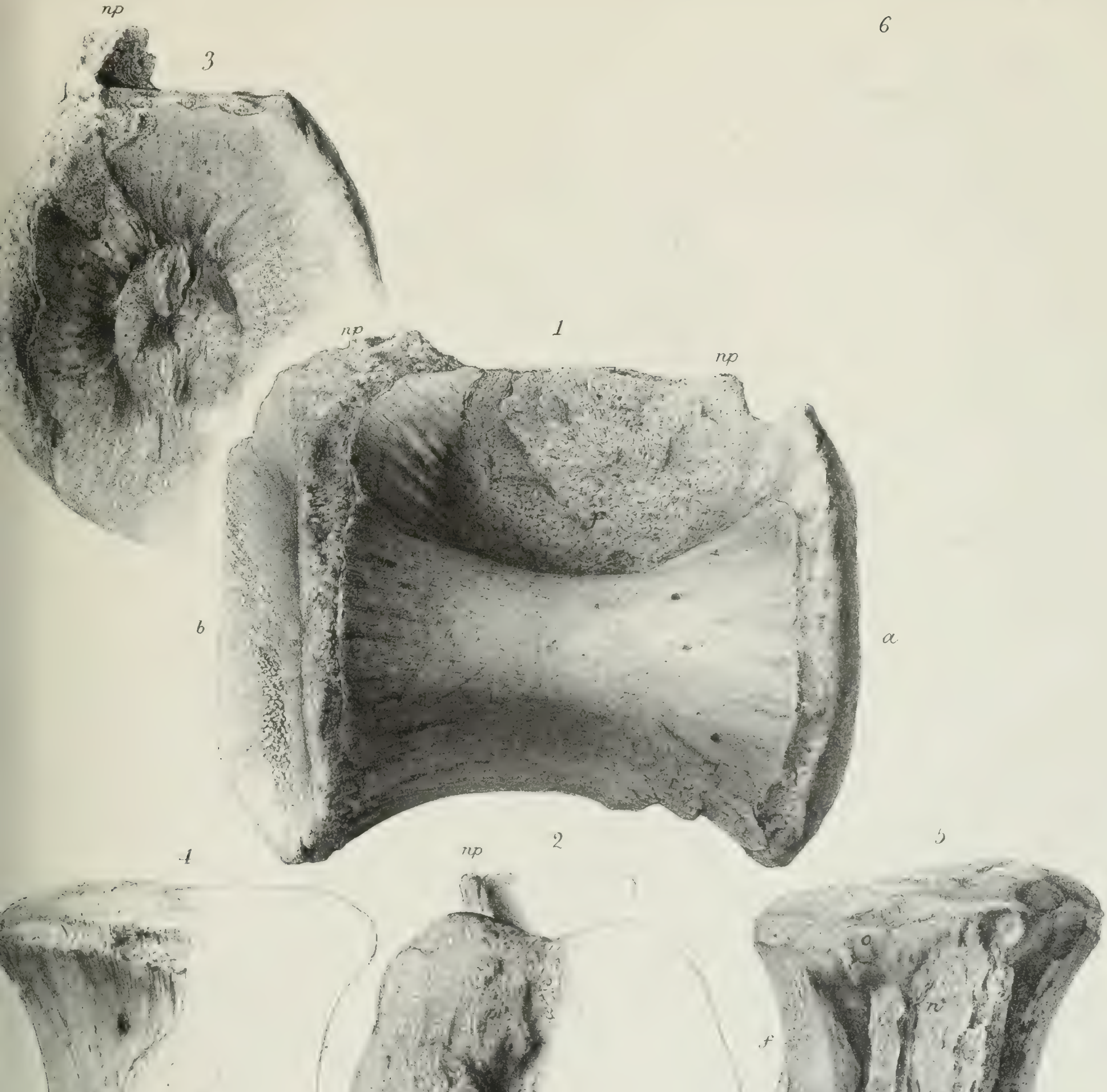
Bothriospondylus suffossus.

Fig.

1. Right side view of centrum of dorso-lumbar vertebra.
2. Part of fore surface of the same, restored in outline.
3. Hind surface of the same.
4. Part of hæmal surface of the same, restored in outline.
5. Neural surface of the same.

All the figures are of the natural size.

From the Kimmeridge Clay at Swindon, Wilts. In the British Museum.



C. L. Griesbach del & lith

M & N Hanhart imp

BOTHRIOSPONDYLUS SUFFOSSUS

PLATE VI.

Bothriospondylus robustus.

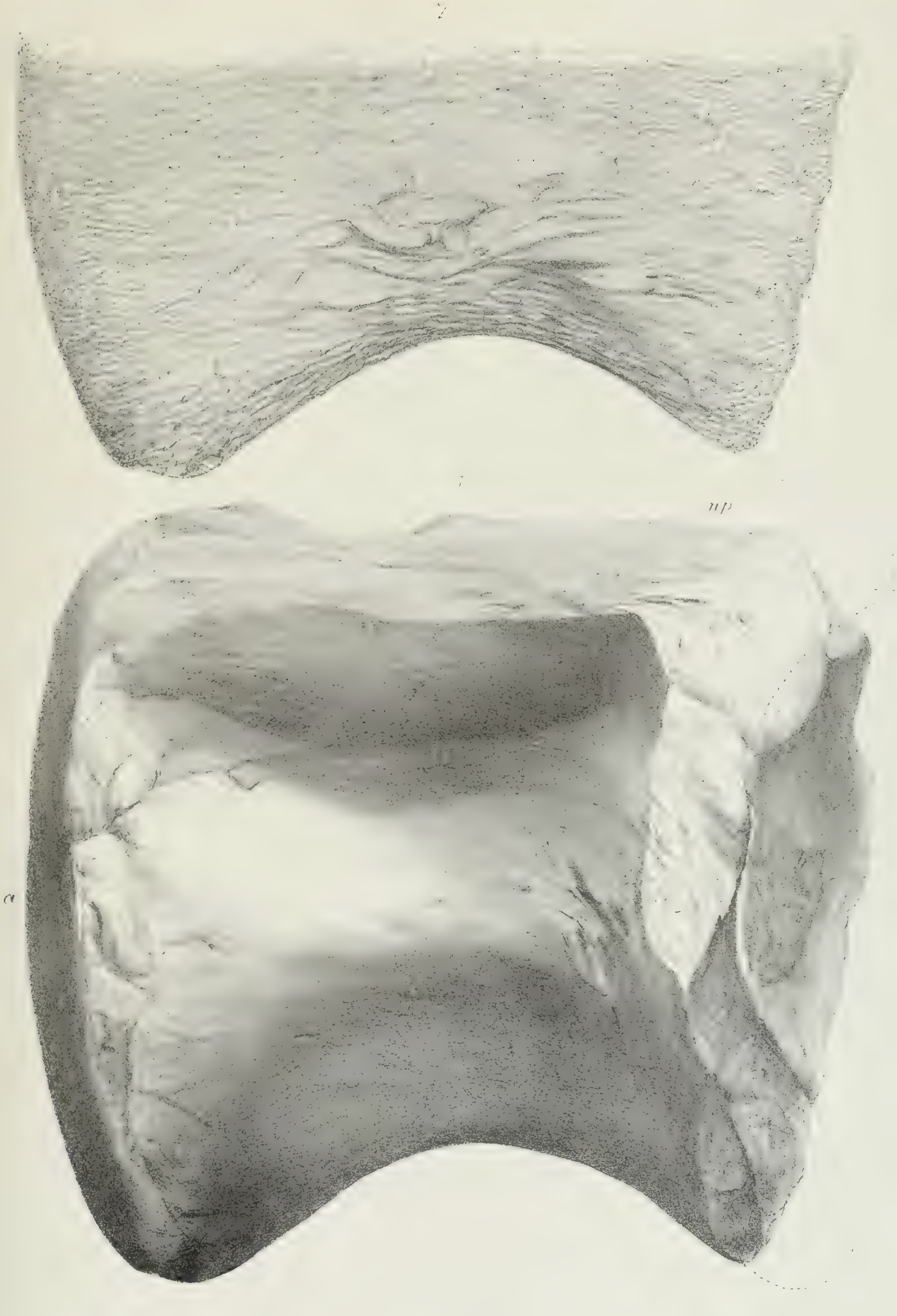
Fig.

1. Left side view of centrum of dorso-lumbar vertebra.

2. Section of the same, showing chondrosal cancelli.

Both figures are of the natural size.

From the Forest Marble of Bradford, Wilts. In the British Museum.



C. L. Griesbach del & lith

M & N. Hanhart imp.

BOTHRIOSPONDYLUS [illegible]

PLATE VII.

Bothriospondylus elongatus.

Right side view of mutilated centrum of dorso-lumbar vertebra, natural size.

From the Wealden of Tilgate. In the British Museum.

PLATE VIII.

Bothriospondylus magnus.

Right side view of centrum of dorsal vertebra, natural size.

From the Wealden of the Isle of Wight. In the British Museum.

BOTHRIOSPONDYLUS MAGNUS

C. L. Griesbach

Mintern Bros. imp

PLATE IX.

Bothriospondylus magnus.

FIG.

1. Fore end of mutilated centrum of dorsal vertebra.
2. Side view of crown of tooth of *Cardiodon rugulosus.*
3. Fore end of the same tooth.
4. Hind end of the crown and beginning of the fang of another tooth of *Cardiodon rugulosus.*
5. Magnified view of markings on the surface of the enamel of the same tooth.

All the figures are of the natural size.

Fig. 1, from the Wealden of the Isle of Wight. In the British Museum.

Figs. 2—5 are copied from Owen's 'Odontography,' 4to, 1840—1845, p. 291, Pl. LXXV, *a* (the subjects were from the Forest Marble at Bradford, Wilts, and formed part of the collection of Channing Pearce, Esq., of that town).

C.L. Griesbach

Mintern Bros imp

BOTHRIOSPONDYLUS MAGNUS

PLATE X.

Cetiosaurus longus

Fig.

1. Side view of dorsal vertebra.

2. Section of part of the same, showing the dense bony texture.

Both figures are of the natural size.

From the Great Oolite at Kirtlington, Oxfordshire. In the Geological Museum, University of Oxford.

Fig. 2.

Fig. 1.

J. L. Griesbach del. et lith.

CETIOSAURUS LONGUS

Mintern Bros. imp.

PLATE XI.

Omosaurus armatus.

Fig.

1. Side-view of neural arch and spine of a cervical vertebra.
2. Upper-view of the same.
3. Side-view of a cervical vertebra of *Varanus niloticus*.
4. Upper-view of the same.

All the figures are of the natural size.

The subject of figs. 1 and 2 is from the Kimmeridge Clay at Swindon, Wilts. In the British Museum.

Fig: 1.

Fig: 4.

Fig: 3.

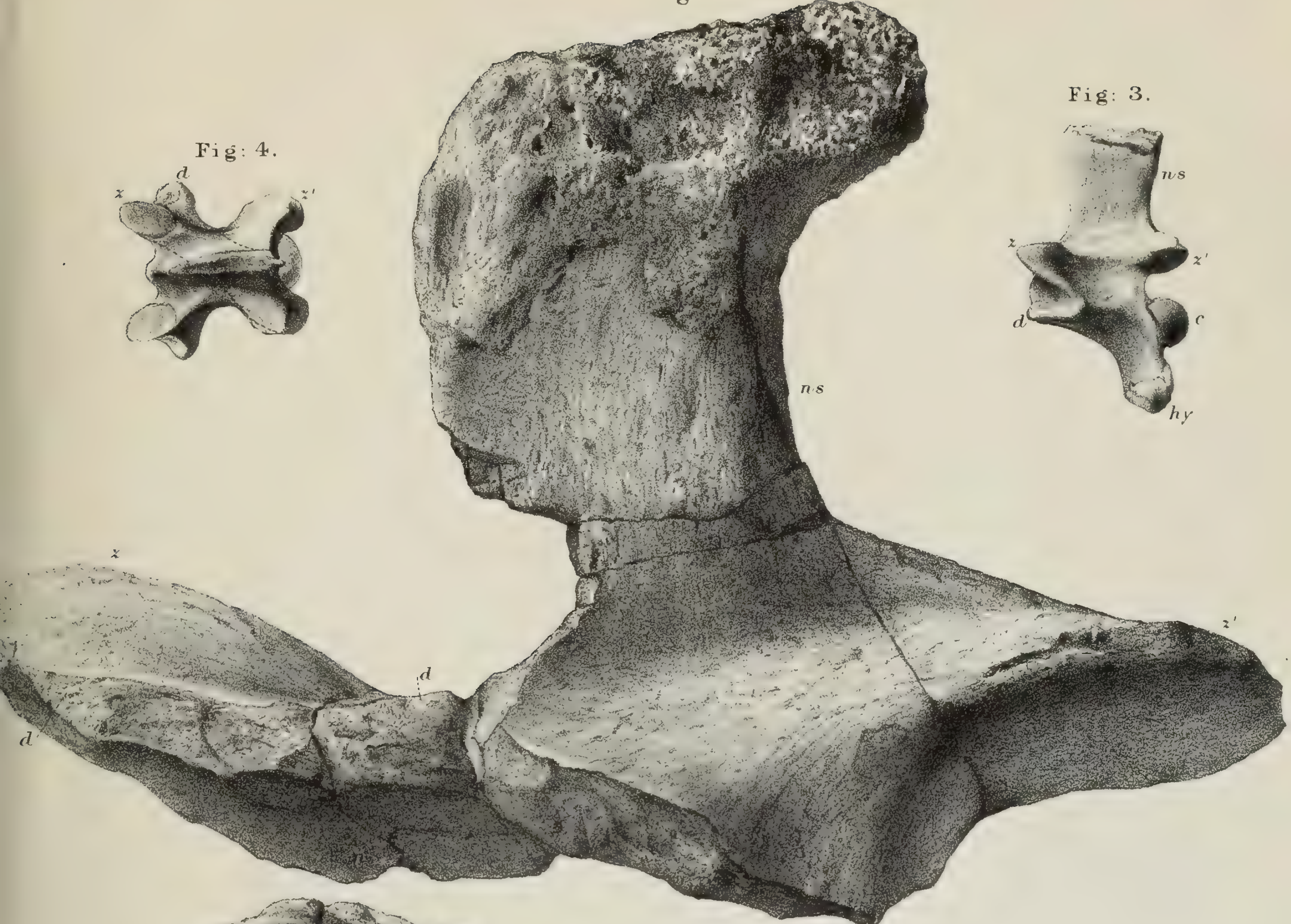


Fig: 2.

PLATE XII.

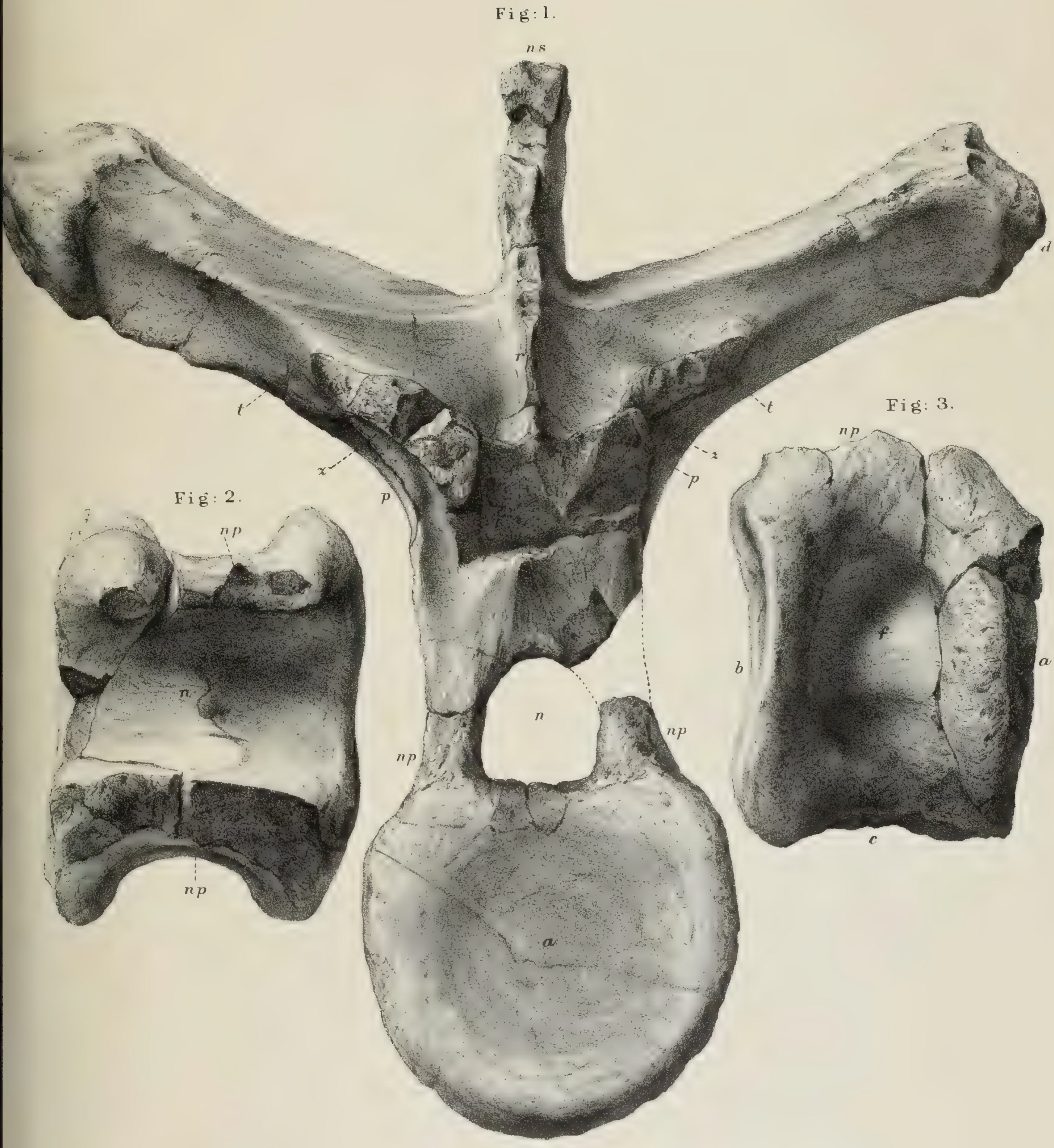
Omosaurus armatus.

Fig.

1. Front-view of a dorsal vertebra.
2. Upper-view of the centrum of a dorsal vertebra.
3. Side-view of the same.

The figures are of half the natural size.

From the Kimmeridge Clay of Swindon, Wilts. In the British Museum.



C.L. Griesbach del et lith

Mintern Bros. imp.

PLATE XIII.

Omosaurus armatus.

Fig.

1. Back-view of the neural arch of the dorsal vertebra, fig. 1, Pl. XII.
2. Side-view of the neural arch of the same vertebra.
3. Side-view of the centrum and base of neurapophysis of the same.

The figures are of half the natural size.

From the Kimmeridge Clay of Swindon, Wilts. In the British Museum.

Fig: 1.

Fig: 2.

Fig: 3.

C.L. Griesbach del. et lith. Mintern Bros imp.

PLATE XIV.

Omosaurus armatus.

FIG.

1. Front-view of an anterior caudal vertebra.
2. Upper-view of end of neural spine.
3. Upper-view of centrum and right pleurapophysis.
4. Under-view of the same.
5. Proximal end of fourth metacarpal.
6. Distal end of the same.

All the figures are of the natural size.

From the Kimmeridge Clay of Swindon, Wilts. In the British Museum.


Fig. 3.
Fig. 2.
Fig. 4.
Fig. 1.
t
pl
pl
t
ns
np
n
np
b
a
z
z'
z
z
n
t
t
pl
pl
Fig 5.
Fig: 6.
a
r

PLATE XV.

Omosaurus armatus.

Fig.

1. Back-view of an anterior caudal vertebra.
2. Right side-view of centrum and neural arch of the same.
3. Left side-view of zygapophyses and neural spine of the same.
4. Proximal end of a terminal or ungual phalanx.
5. Distal end of the same.

All the figures are of the natural size.

From the Kimmeridge Clay at Swindon, Wilts. In the British Museum.


Fig: 2.
Fig. 3.
Fig. 1.
Fig. 5.
Fig: 4.

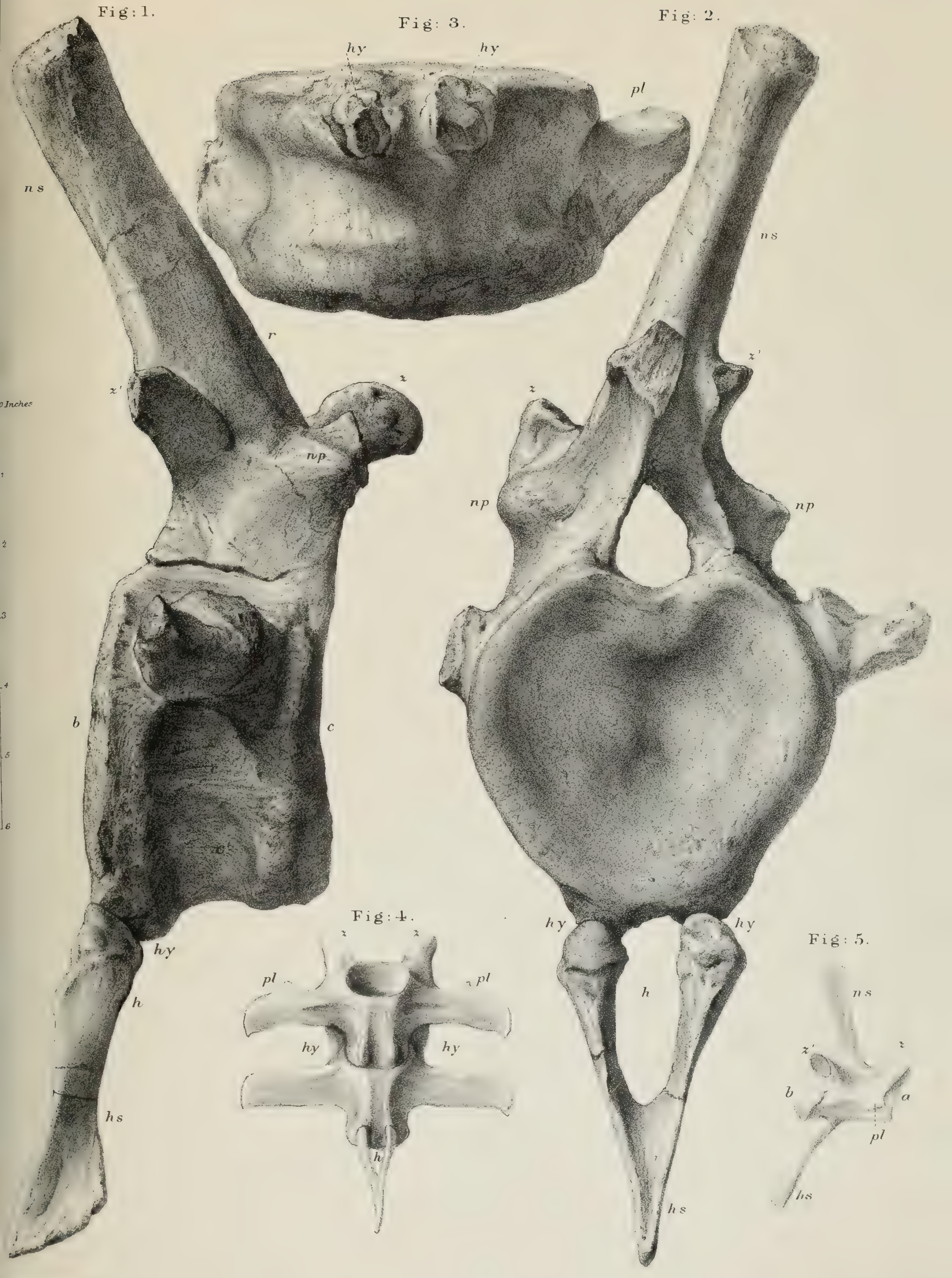
PLATE XVI.

Omosaurus armatus.

Fig.

1. Side-view of a middle caudal vertebra.
2. Back-view of the same.
3. Under-view of the centrum of the same.
4. Under-view of two middle caudal vertebræ, the foremost wanting its hæmal arch, of *Monitor niloticus*.
5. Side-view of a middle caudal vertebra of the same.

Figs. 1—3 are figured a little more than half the natural size; figs. 4 and 5, natural size. The subject of figs. 1—3 is from the Kimmeridge Clay at Swindon, Wilts. In the British Museum.



Griesbach del. et lith

Mintern Bros. imp

PLATE XVII.

Omosaurus armatus.

Fig.

1. Thenal or palmar surface of the left humerus.
2. Anconal surface of the same.
3. Proximal end of the same.
4. Distal end of the same.
5. Transverse section of narrowest part of the shaft of the same.
6. Thenal surface of the left humerus of a *Monitor niloticus*.
7. Anconal surface of the left radius.
8. Thenal surface of the same.
9. Proximal end of the same.
10. Distal end of the same.
11. Transverse section of narrowest part of the shaft of the same.
12. Thenal surface and proximal end of the left radius of a *Monitor niloticus*.
13. Radial surface of the left ulna.
14. Ulnar surface of the same.
15. Radial surface of the left ulna of a *Monitor niloticus*.

Figs. 1—5, 7—11, 13 and 14, are figured one fourth the natural size, from the Kimmeridge Clay at Swindon, Wilts. In the British Museum. Figs. 6, 12, 15, are of the natural size.

C L Griesbach del et lith

Mintern Bros imp

PLATE XVIII.

Omosaurus armatus.

Fig.

1. Anconal surface of the fourth left metacarpal.
2. Radial surface of the same.
3. Anconal surface of a third left metacarpal.
4. Ulnar surface of the same.
5. Proximal end of the same.
6. Distal end of the same.

All the figures are two thirds the natural size.

From the Kimmeridge Clay at Swindon, Wilts. In the British Museum.

Fig: 1.

$\frac{2}{3}$

Fig: 2.

Fig: 5.

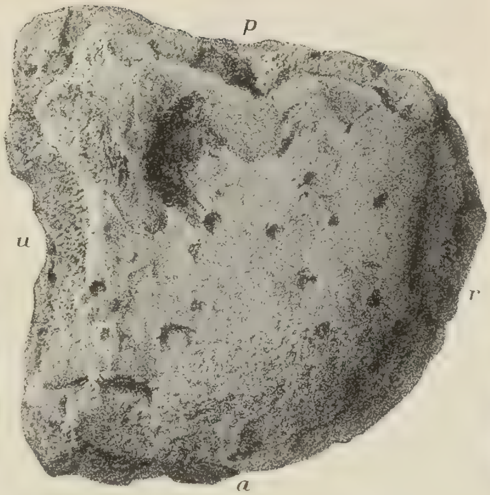


Fig: 6.

Fig: 3.

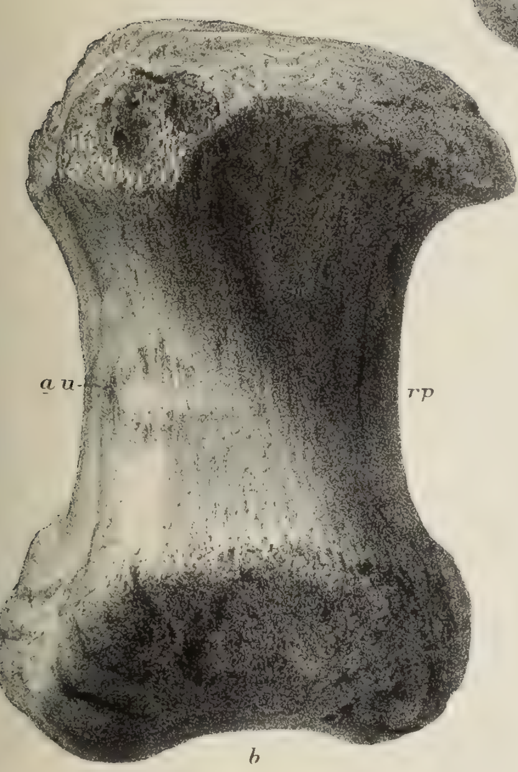


Fig: 4.

Griesbach del et lith

Mintern Bros imp

PLATE XIX.

Omosaurus armatus.

Hæmal or under-view of the pelvis, with contiguous dislocated vertebræ and a right femur.

One eighth the natural size.

From the Kimmeridge Clay at Swindon, Wilts. In the British Museum.

C. L. Griesbach del. et lith.
Mintern Bros. imp.

PLATE XX.

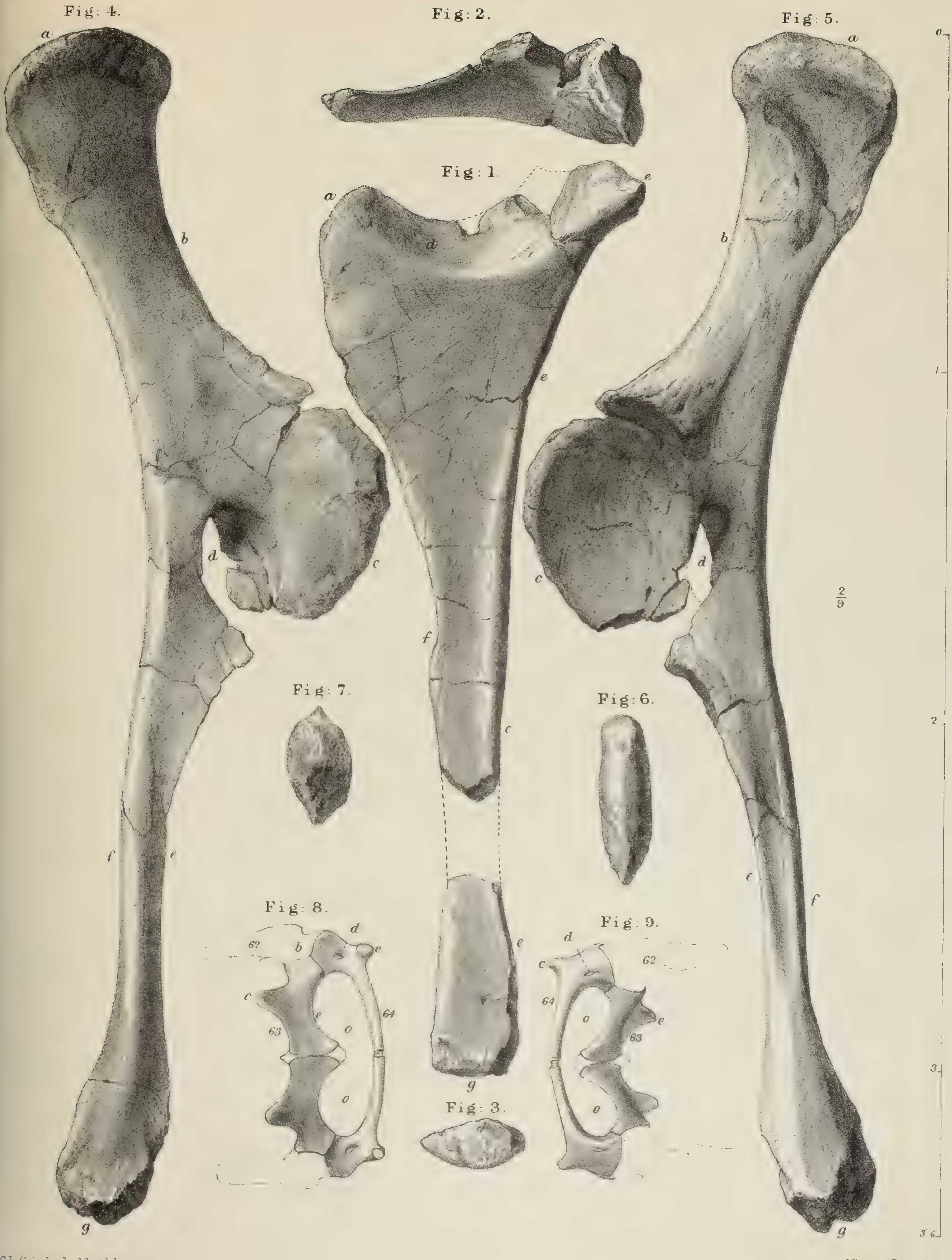
Omosaurus armatus.

Fig.

1. Hæmal or under surface of the ischium.
2. Proximal or acetabular end of the same.
3. Distal or symphysial end of the same.
4. Hæmal or under surface of the right pubis.
5. Neural or upper surface of the same.
6. Proximal end of the same.
7. Distal end of the same.
8. Hæmal or under surface of the pelvis of an Egyptian Lizard (*Uromastyx spinipes*).
9. Neural or upper surface of the same.

Figs. 8 and 9 are of the natural size; the other figures are two ninths the natural size.

The subjects of the latter are from the Kimmeridge Clay at Swindon, Wilts. In the British Museum.



C.L. Griesbach del et lith

Mintern Bros imp

PLATE XXI.

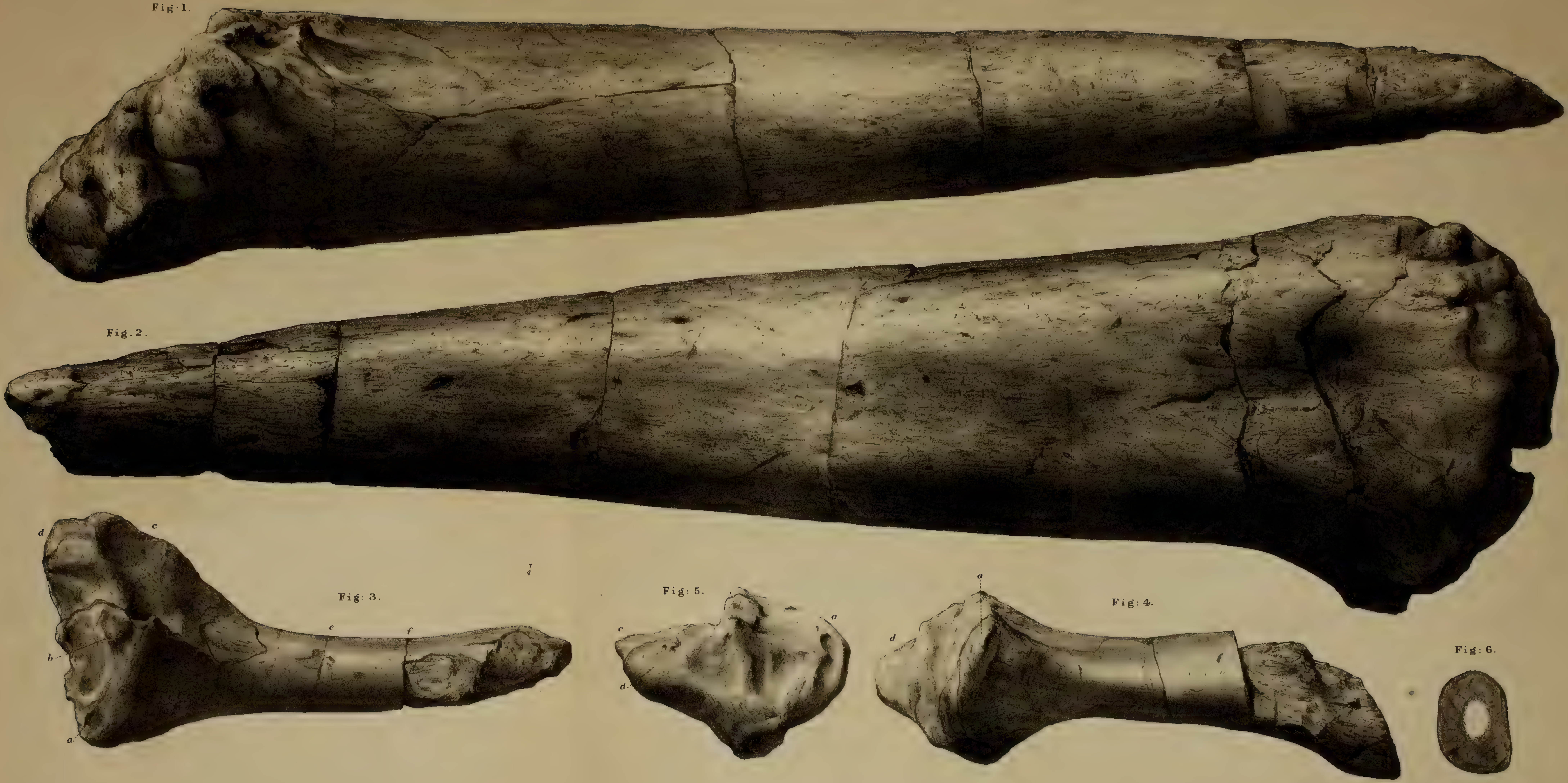
Omosaurus armatus.

FIG.

1. Radial side of left carpal spine.
2. Anconal side of the same.
3. Fibular side of right tibia.
4. Popliteal side of the same.
5. Proximal end of the same.
6. Transverse section of narrowest part of the shaft of the same.

Figs. 1 and 2 are of the natural size; figs. 3—6 are one fourth the natural size.

From the Kimmeridge Clay at Swindon, Wilts. In the British Museum.



C.L. Griesbach del et lith.

Mintern Bros imp.

PLATE XXII.

Omosaurus armatus.

Fig.

1. Section of the centrum of a sacral vertebra.
2. Base of the left carpal spine.
3. Section near the middle of the same.

From the Kimmeridge Clay at Swindon, Wilts. In the British Museum.

Fig: 1.

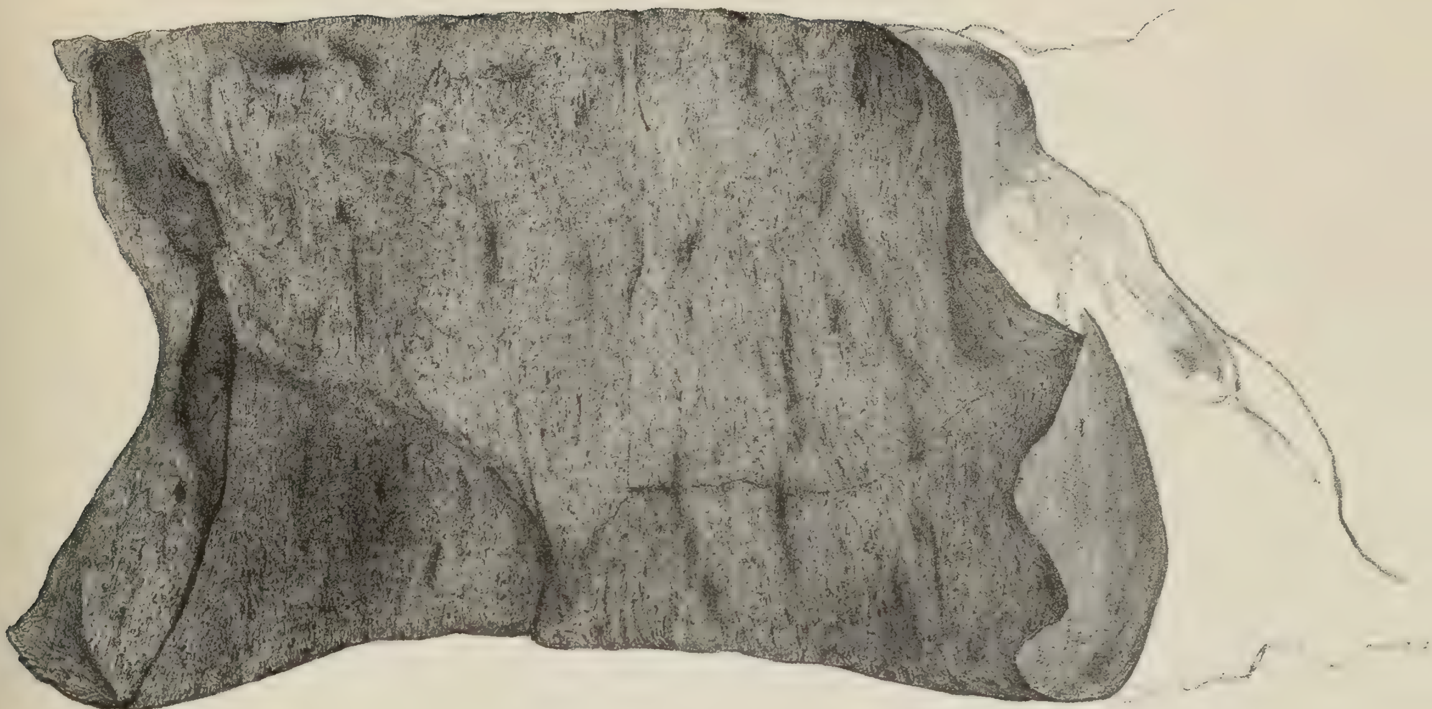


Fig: 2.

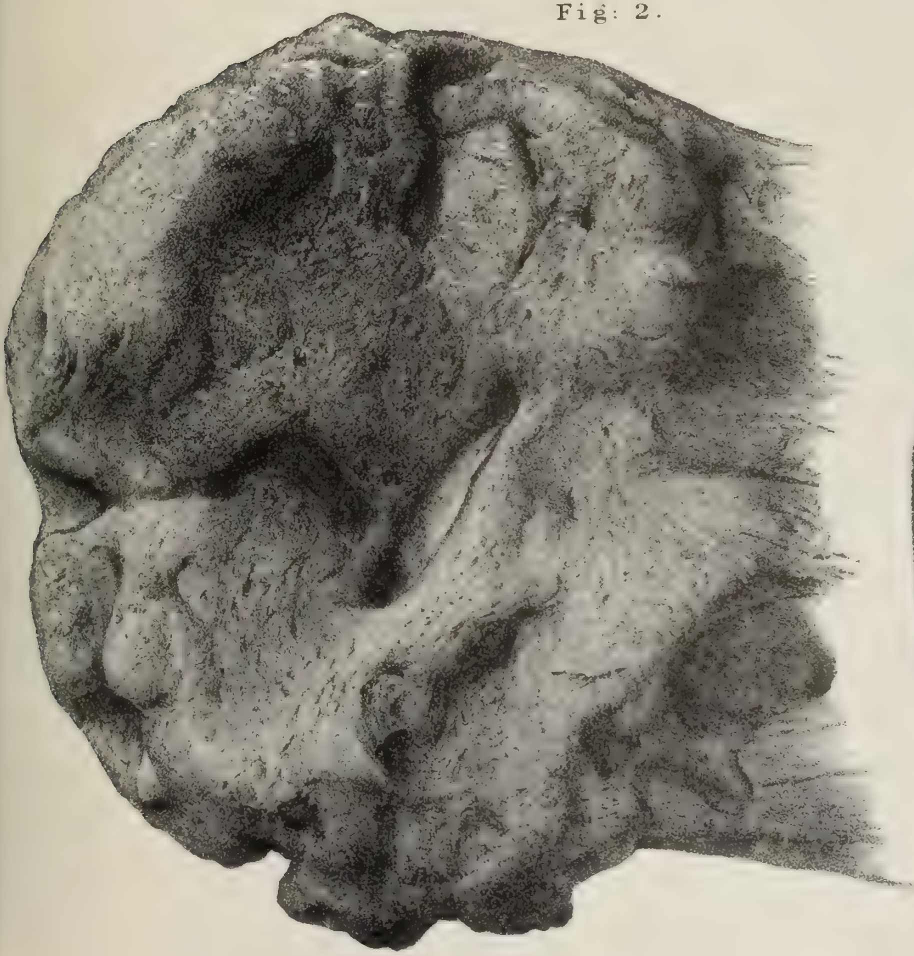


Fig: 3.

C.L. Griesbach del. et lith

Mintern Bros imp